APOLLO G&N Specification
PS6015000 REV A
Original Issue Date:
Release Authority: TDRR 2534
Class A Release
CODE IDENT NO. 80230

MASTER END ITEM DETAIL SPECIFICATION

PART II

PRODUCT CONFIGURATION AND ACCEPTANCE TEST REQUIREMENTS

PGNCS SPACECRAFT EQUIPMENT

LEM

DRAWING NO. 6015000

MEI NO. 6015000

Record of Revisions

Date	Revision Letter	TDRR No.	Pages Revised	Approvals MIT	Approvals NASA
3/16/66	A	27208	4, 6-33 now 34 pages was 33.	WK	TM

This specification consists of page 1 to 34 inclusive.

APPROVALS	NASA/MSC	15 Jan 1966	MIT/IL	19 Jan 66	ACSP

3. REQUIREMENTS

3.1 PERFORMANCE

3.1.1 Standby Control

3.1.1.1 LEM Standby Mode. The following requirements shall be met with the IMU in the standby condition.

3.1.1.1.1 28 VDC IMU Standby. The IMU Standby voltage shall be 22.0±1.0 vdc.

3.1.1.1.2 Inertial Component Temperature. The PIPA temperature shall be 130±1.5°F. The IRIG temperature shall stabilize to within 1.0°F of the PIPA temperature within 1 hour after entering the Standby Mode.

3.1.1.2 G&N Standby Mode (LGC STBY). The following requirements shall be met with the IMU in the standby condition and the LGC in the standby condition.

3.1.1.2.1 28 VDC IMU Standby. The IMU Standby voltage shall be 28.0±1.0 vdc.

3.1.1.2.2 3200 cps Suspension Power. The 3200 cps suspension voltage shall be 28.6±0.56 volts rms at a frequency of 3200±1 cps.

3.1.1.2.3 Master Clock Sync. The Master Clock Sync signal characteristics shall be as follows. (See Figure 1).

a. Amplitude: 4.0 volts minimum.
b. Pulse Width: 0.50±0.25 microseconds.
c. Rise Time: 0.2 microseconds max. from 10 to 90 percent of amplitude.
d. Frequency: 1024K pps ±2 ppm over a 15 minute period.

3.1.1.3 G&N Standby Mode (LGC Operate). The following requirements shall be met with the IMU in the standby condition, the LGC in the operate condition, and the LGC +4 and +14 volt dc power supplies at 4.0±0.15 and 14.0±0.2, respectively.

3.1.1.3.1 Inhibit Power Fail. A LGC Warning discrete caused by a Voltage Fail alarm shall not occur with the Inhibit Power Fail discrete present at the LGC.

3.1.1.3.2 Low Voltage.

3.1.1.3.2.1 Voltage Fail Alarm. A Voltage Fail alarm shall occur, as indicated by the presence of a LGC Warning discrete, when the power supply outputs are independently decreased as follows:

a. The 4 vdc power supply output shall be decreased from nominal to 3.60±0.05 vac.
b. The 14 vdc power supply output shall be decreased from nominal to 12.6±0.2 vdc.

3.1.1.3.2.2 LGC Fail Indication. Any of the LGC Fail indications may be present when the Inhibit Power Fail discrete is present as the power supply outputs are independently decreased as follows:

a. The 4 vdc power supply output shall be decreased to a maximum low of 2.5 vdc.
b. The 14 vdc power supply output shall be decreased to a maximum low of 8.0 vdc.

3.1.1.3.3 High Voltage

3.1.1.3.3.1 Voltage Fail Alarm. A Voltage Fail alarm shall occur, as indicated by the presence of a LGC Warning discrete, when the power supply outputs are independently increased as follows:

a. The 4 vdc power supply output increased from nominal to 4.5±0.2 vdc.
b. The 14 vdc power supply output increased from nominal to 16.2±0.2 vdc.

3.1.1.3.3.2 LGC Fail Indication. Any of the LGC Fail indications may be present when the Inhibit Power Fail discrete is present as the power supply outputs are independently increased as follows:

a. The 4 vdc power supply output shall be increased to a maximum high of 5.2 vdc.
b. The 14 vdc power supply output shall be increased to a maximum high of 16.5 vdc.

3.1.1.4 Reticle Lamp Voltage. The variable AOT Reticle Lamp Voltage shall have the following characteristics at the interface:

a. Minimum Voltage: less than 0.27 vdc
b. Maximum Voltage: 4.67 vdc

3.1.2 Operate Control

3.1.2.1 IMU Operate Delay Indication. LGC Channel 30 shall indicate a "0" in bit 14 when the system is supplied with the +28.0±0.5 VDC IMU Operate power and shall remain in the "0" state for 90±5 seconds, after which time bit 14 of Channel 30 and bit 15 of Channel 12 shall indicate a "1".

3.1.2.1.1 Inertial Component Pulse Torquing. During the 90 second delay period, the IRIG and PIPA pulse torque power supply shall be inhibited. Loss of +28 VDC LGC prime power shall result in the same condition.

3.1.2.1.2 Automatic Caging and CDU Ambiguity Operation. The IMU gimbal resolvers shall drive until the 1X sine signals indicate 0.00±0.50 volts rms and the 1X cosine signals indicate 26.0±2.6 volts rms, with the IMU gimbal angles initially at 225°.

3.1.2.2 Inertial Component Temperature. The following requirements shall be met in the Operate mode with IMU gimbal angles of 0° ±5°.

3.1.2.2.1 Standby to Operate Transient. The PIPA temperature, 15 minutes after switching from the Standby mode to the Operate mode, shall be within 2.0°F of the temperature specified in 3.1.1.1.2.

3.1.2.2.2 Inertial Temperature Control Point. The IRIG and PIPA temperature, 15 minutes after switching from the Standby to Operate mode, shall be 135° ±1°F and 130° ±1.0°F, respectively. The IRIG and PIPA temperature shall remain stable to within ±0.2°F for a period of one hour thereafter.

3.1.2.2.3 Heater Telemetry Discrete. The Heater Telemetry Discrete shall cycle ON and OFF. The ON state shall be 28±1 vdc at the interface.

3.1.2.2.4 Blower Telemetry Discrete. The Blower Telemetry Discrete shall remain in the ON state and shall be 28.0±1.4 at the interface.

3.1.2.3 800 CPS Power Supply Temperature. The indicated 800 cps power supply temperature shall be 70° ±40°F.

3.1.2.4 Temperature Monitor 1. The indicated temperature monitor 1 shall be 75° ±45°F.

3.1.2.5 Calibration Module Temperature. The indicated calibration module temperature shall be 57.5° ±27.5°F.

3.1.2.6 +28 VDC IMU Operate. The IMU Operate voltage shall be 28.5 +0, -1 vdc.

3.1.3 System Power Supplies. The system power supplies shall meet the following requirements.

3.1.3.1 IMU 28V, 1 Percent, 800 CPS Supply

3.1.3.1.1 Voltage. The output voltage shall be 28.00±0.56V rms.

3.1.3.1.2 Frequency. The output frequency shall be 800±1 cps.

3.1.3.2 IMU 28V, 5 Percent, 800 CPS Supplies (Phases A and B)

3.1.3.2.1 Voltage. The output voltage of phase A shall be 28.0±1.4V rms and the output voltage of phase B shall be 28.0±2.1V rms.

3.1.3.2.2 Frequency. The frequency of the power supply outputs shall be 800±1 cps.

3.1.3.2.3 Phase. The output of the phase A supply shall be -90° ±10° with respect to the IMU 28V, 1 percent power supply output. The output of the phase B supply shall be -90° ±10° with respect to the IMU 28V, 5 percent, phase A power supply output.

3.1.3.3 ECDU +4 VDC Supply. The ECDU +4 vdc supply output voltage shall be +4.0±0.2 vdc.

3.1.3.4 Minus 28 VDC Supply. The -28 vdc supply output voltage shall be -27.5±6.0 vdc.

3.1.3.5 Pulse Torque Power Supply. The pulse torque power supply outputs shall be as follows at the interface.

	OUTPUT	VOLTAGE
a.	120 vdc (1)	120±6 vdc
b.	28 vdc (PVR) (3)	28.0±1.4 vdc

3.1.3.6 800 CPS Reference Voltage. The reference voltage at the interface shall have the following characteristics.

3.1.3.6.1 Amplitude. The amplitude shall be 28.00V rms ±2 percent.

3.1.3.6.2 Frequency. The frequency shall be 800±1 cps.

3.1.3.6.3 Instantaneous Voltage. The amplitude shall not exceed 45V rms and shall return to 28.0±2.0 percent within 5 seconds after application of 28 VDC IMU Operate power.

3.1.3.7 3200 CPS Suspension Power. The 3200 cps suspension power supply shall have the following characteristics with the LGC in Standby or Operate.

3.1.3.7.1 Voltage. The Feedback voltage of the 3200 cps supply shall be 28.00±0.56V rms.

3.1.3.7.2 Frequency. The frequency shall be 3200±1 cps.

3.1.3.7.3 Phase. The phase angle of the 3200 cps supply shall be at 0° ±10° with respect to the 3200 pps synchronizing pulse train.

3.1.3.8 LGC +4 VDC Power Supply. The output voltage of the LGC +4 vdc power supply shall be +4.00±0.15 vdc.

3.1.3.8.1 Noise. The peak-to-peak noise level shall be 0.4 volt or less.

3.1.3.8.2 ACE Bias 1. The +4 vdc power supply output shall drop by 0.35±0.15 vdc with the requirements of 4.2.1.4.2.6 met.

3.1.3.9 LGC +14 VDC Power Supply. The output voltage of the LGC +14 vdc power supply shall be +14.00±0.20 vdc.

3.1.3.9.1 Noise. The peak-to-peak noise level shall be 0.4 volt or less.

3.1.3.9.2 ACE Bias 2. The +14 vdc power supply output shall drop by 1.2±0.4 vdc with the requirements of 4.2.1.4.2.6 met.

3.1.3.10 LGC +28 VDC. The +28 vdc COMP TP voltage shall be +28.0 +5.5, -3.5 vdc.

3.1.4 LEM Guidance Computer (LGC)

3.1.4.1 Operational Self-Check. The LGC program shall sum fixed memory; verify the execution of the machine instructions, control pulses, interupts, and timing; and exercise the erasable, central, and special registers. In addition, the program shall verify the proper operation of all electro-luminescent displays on the DSKY.

3.1.4.2 Keyboard Operation. Actuation of each listed pushbutton shall result in a displayed indication as follows:

a. Verb: (preceding and in conjunction with two numeral pushbuttons) shall result in the illumination of the same numerals in the VERB display window.

b. Noun: (preceding and in conjunction with two numeral pushbuttons) shall result in the illumination of the same numerals in the NOUN display window.

c. 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, +, - : shall result in illumination of the respective characters on the DSKY display.

d. CLR: shall result in deletion of illuminated characters on R-1, R-2, and R-3 during a data load sequence on the DSKY display, provided the ENTER pushbutton has not been pressed during the entry sequence.

e. STBY: shall extinguish all DSKY illumination except that of the STBY RESTART and TEMP lamps after preparing the LGC for STBY.

f. CAUT RSET: shall extinguish any or all of the following DSKY display lamps when illuminated.

(1) PROG
(2) RESTART
(3) OPR ERR

g. KEY REL: shall extinguish the KEY REL DSKY display lamp and return the DSKY control to the monitoring routine which is commanded by the LGC.

h. ENTER: shall result in the completion of a legal entry depending upon the actuation of the proper sequence of VERB, or VERB, NOUN, plus numeral pushbuttons.

3.1.4.3 Display Operation. Each listed display lamp shall illuminate as a result of specified stimuli.

a. All listed lamps (b through m) shall be capable of lamp element operation verification through the use of VERB 35.

b. STBY: shall illuminate after actuation of the STBY pushbutton for at least 2 seconds after preparing the LGC for STBY.

Channel 6	Bit No.	Channel 6	Bit No.
+Y RCS Jet 2S	5	+Z RCS Jet 3F	1
+Y RCS Jet 1S	8	+Z RCS Jet 2F	4
-Y RCS Jet 4S	7	-Z RCS Jet 4F	2
-Y RCS Jet 3S	6	-Z RCS Jet 1F	3

3.1.4.5 LGC Commands to Main Engine. The interface shall exhibit the following pulse characteristics upon command from the LGC.

a. Increase Throttle Rate Descent Engine
b. Decrease Throttle Rate Descent Engine

3.1.4.5.1 Pulse Characteristics (See Figure 1)

a. Amplitude (A): 7±3V
b. Width at A/2 Point: 3±1 μsec
c. Droop: 20 percent at 2 μsec from A peak
d. Backswing: 4 volts peak with respect to the amplitude reference level
e. Risetime: 0.2 μsec max (10 percent to 90 percent of A)
f. Repetition Rate: 3.2K pps
g. Max Noise: +0.4 to -4.0 volts with respect to the amplitude reference level.

3.1.4.6 LGC Commands to Stabilization Control System. The following interface shall exhibit 5 vdc or less for a logic 1, or 10±1 vdc for a logic 0, command to the specified bit assignments of LGC CH 11 and CH 12.

Interface	Bit	Channel
Engine On Asc or Desc	13	11
Engine Off Asc or Desc	14	11
+Pitch Gimbal Trim	9	12
-Pitch Gimbal Trim	10	12
+Roll Gimbal Trim	11	12
-Roll Gimbal Trim	12	12

3.1.4.7 LGC Discrete Inputs. Each interface specified below, when excited in accordance with the appropriate voltage specified in 4.2.1.4.2, shall cause the proper bit states as specified in Table I.

3.1.4.7.1 Mark X. Actuation of the MARK X pushbutton shall cause a "1" to be present in bit 3 of CH 16.

3.1.4.7.2 Mark Y. Actuation of the MARK Y pushbutton shall cause a "1" to be present in bit 4 of CH 16.

3.1.4.7.3 Mark Reject. Actuation of the MARK REJECT pushbutton shall cause a "1" to be present in bit 5 of CH 16.

3.1.4.8 Landing Radar (LR) Requirements. The LR Read Cycle shall be commanded by LGC program. The Read Cycle shall consist of a constant 3200 cycle pulse train output (LR Gate Reset Strobe) in conjunction with one of four 3200 Gate Strobes (X_A, Y_A, Z_A or Range). Subsequent to issuance of the Gate Strobe, a Read Out Sync burst shall be commanded. Each Gate Strobe shall be commanded in conjunction with the Reset Strobe and Read Out Sync burst and shall appear at the interface.

3.1.4.8.1 Pulse Characteristics and Data Acquisition. With the conditions as specified in 3.1.4.8, and with the LR Range Data Good discrete present at the LGC interface when using the LR Range Gate Strobe; or with the LR Velocity Data Good discrete present at the LGC interface when using either Velocity Gate Strobe; the following pulse and data acquisition characteristics of the interface specified in 3.1.4.8 shall be as follows. (See Figure 1 for wave shape description.)

a. Amplitude (A): 7±3V peak-to-peak

b. Pulse Width at A/2 Point: 3.0±0.5 microseconds

c. Droop: 20 percent of A at 2 microseconds

d. Maximum Backswing: 4 volts peak

e. Risetime: 0.2 microseconds from 10 to 90 percent of A

f. Frequency: 3.2K pps

g. Noise: No pulse <+0.4 volts peak

h. Gate Strobe Timing: LR Radar Gate Reset Strobe pulse shall lead either LR Range or Velocity Gate Strobe pulse by 2.0±0.25 microseconds as determined at the respective A/2 points.

i. Read Cycle Timing: The elapsed time between issuance of the first Gate Strobe pulse and the first Read Out Sync pulse shall be not less than 80.315 milliseconds.

3.1.4.8.2 Data Acquisition Characteristics. A known sequence of LR "0"s and LR "1"s shall result in duplication of the specified sequence in counter 46 of LGC.

3.1.4 8.3 LR Antenna Position Command. With a "1" in bit 13 of CH 12, the interface shall exhibit less than 5 vdc. With a "0" in bit 13 of CH 12, the interface shall exhibit 10±1 vdc.

3.1.4.9 Attitude Hand Controller. The specified quantized values shall be exhibited by the LGC with given hand controller inputs at the interface.

	Roll, Pitch or Yaw Controller Inputs (volts rms)	Quantized Value, LGC Display
a.	0.080	00000±0
b.	0.900	00012±1
c.	1.800	00025±2
d.	2.700	00037±3

3.1.4.9.1 Attitude Control Out of Detent. With the Attitude Control Out of Detent discrete present, a "0" shall be present in bit 3 of CH 31.

3.1 4.10 Telemetry Uplink (UPLINK "0", UPLINK "1"). A block Uplink discrete of a "0" in Channel 33, bit 10 in accordance with 4.2.1.4.2 shall enable the acceptance of Uplink Data.

3.1.4.10.1 Transmission Verification. Interrogation of the LGC erasable memory shall determine if a known sequence of "0"s and "1"s applied, at the interface is accepted by the LGC.

3.1.4.10.2 Telemetry Verification. With a pulse train of all "0"s and all "1"s applied to the interface as specified in 3.1.4.10.1, the amplitude of the "0"s pulses shall be 0.0±0.4V relative to a "0" level of 7±3V peak to peak, and the amplitude of the "1"s pulses shall be 7±3V peak to peak.

3.1.4.11 Telemetry Downlink. With the Dlnk Start, Dlnk End and Dlnk Sync signals in accordance with the requirements of 4.2.1.4.2, and with Dlnk Start and End pulses occurring at 10 or 50 pps, a 33-bit word shall be present at a word or burst frequency of 10 or 50 per second.

3.1.4.11.1 Downlink Data. The "1" pulse shall have the following characteristics:

a. Amplitude (A): 7±2V pp
b. Width at A/2: 2 to 6 μsec
c. Maximum Droop at 2.0 μsec following the leading edge: 20 percent of A
d. Maximum risetime at 10 to 90 percent of A: 0.2 μsec
e. Maximum delay with respect to the bit sync pulse: 1.0 μsec
f. Noise (Zero Pulse): +0.4V max, -6V max

3.1.4.11.2 Downlink Too Fast. With Dlnk Start and End pulses occurring at a rate in excess of 100 pps, bit 12 of CH 33 shall be a "0".

3.1.4.12 LGC Warning. The LGC Warning discrete shall occur as a result of any or all of the following conditions.

a. RESTART
b. COUNTER FAIL
c. VOLTAGE FAIL (in standby mode)
d. LIGHT TEST
e. Scalar double alarm
f. SCAFAL
g. LGC +28 VDC FAIL

3.1.4.13 ISS Warning. The ISS Warning discrete shall occur as a result of a "1" in bit 1 of CH 11.

3.1.4.14 PGNS Caution. The PGNS Caution discrete shall occur as a result of any or all of the following conditions:

a. Program Caution: a "1" in bit 9 of RLYWD 1100
b. Temperature: a "1" in bit 4 of CH 11
c. Gimbal Lock: a "1" in bit 6 of RLYWD 1100
d. Tracker: a "1" in bit 8 of RLYWD 1100
e. RESTART

3.1.4.15 Altitude Meters. The LGC shall command known data words, Altitude "0", Altitude "1", Altitude Rate "0", and Altitude Rate "1". The pulse characteristics of the data words shall be as follows:

a. Amplitude (A): 7±3V
b. Pulse Width at A/2 Point: 3±1 microsec
c. Droop: 20 percent of A at 2 microsec
d. Maximum Backswing: 4V
e. Risetime: 0.2 microsec max from 10 percent to 90 percent of A
f. Frequency: 3.2K pps±1 pps.

3.1.4.16 Rendezvous Radar (RR). The RR Read Cycle shall be commanded by LGC program. The Read Cycle shall consist of a constant 3200 cycle pulse train output (RR Gate Reset Strobe) in conjunction with one of two Gate Strobe (Range or Range Rate) outputs. Subsequent to issuance of the Gate Strobe, the Read Out Sync burst shall be commanded. Each Gate Strobe shall be commanded in conjunction with the Reset Strobe and Read Out Sync burst and shall appear at the interface.

3.1.4.16.1 Pulse Characteristics and Data Acquisition. Under the conditions of 3.1.4.16, and with the RR Data Good discrete present at the LGC interface as demonstrated by a "1" in bit 4 of CH 33, the following pulse and data acquisition characteristics shall exist.

3.1.4.16.1.1 Pulse Characteristics. The pulse characteristics of the pulse signals specified in 3.1.4.16 shall be as follows. (See Figure 1 for the wave shape requirements.)

3.1.5.2.2 AC D/A Command. The IMU CDU AC D/A output at the interface shall not exceed 0.30V rms subsequent to completion of torquing command.

3.1.5.2.3 Torquing Rate. The CDU, when stimulated by the maximum LGC torquing command, shall exhibit an average gimbal torquing rate of 16±2 degrees per second over a minimum range of 67.5 degrees.

3.1.5.3 Fine Align. The mode shall be initiated by entering Verb 42 at the LGC DSKY.

3.1.5.3.1 CDU Lead Repeatability Accuracy. The LGC shall be capable of repeating given IG and OG angles in each quadrant to within ±1 bit. The same repeating accuracy shall be met for MG angles of less than ±70.0 degrees.

3 1.5.3.1.1 CDU Read Ambiguity. The IG and OG CDU's shall be capable of repeating an angle of 225 (-135) ±2 degrees to within 1 bit.

3.1.5.3.2 CDU Fine Error. The dynamic error at the interface shall not exceed 0.070 volts rms through out a range of 22.5 degrees of IMU gimbal rotation.

3.1.5.3.3 CDU Coarse Error. The dynamic error at the interface shall not exceed 0.680 volts rms through an inner and outer IMU gimbal rotation of 360° and a middle gimbal rotation of ±67.5°.

3.1.5.3.4 IMU CDU Fail. CDU Fail indicated by a "0" in bit 12 of CH 30 shall occur with a difference of 1.0° ±0.1° (fine error) or 33.75° ±0.3° (coarse error) between the CDU read counter and the IMU gimbal resolvers.

3.1.5.4 FDAI Linearity. The LGC shall command the following angular increments to each CDU resulting in the voltage and phase outputs as specified at the interface.

Increment (deg)	CDU A/C DAC Error (volts)	Phase wrt ref)
+17	+5.05 ±10%	in
+16	+4.86 ±10%	in
+6	+1.8 ±10%	less than 8° shift
0	0.056 max	N/A
-6	-1.8 ±10%	out
-16	-4.86 ±10%	out
-17	-5.05 ±10%	out

3.1.5.5 Total Attitude (GASTA) Interface. With the IMU gimbal angles at 45.0° the output at the interface shall be 18.4±1.84V.

a. Cos AIG 1X
b. Sin AIG 1X

c. Cos AMG 1X
d. Sin AMG 1X
e. Cos AOG 1X
f. Sin AOG 1X

3.1.5.5.1 Phase Shift. The phase of the cosine output shall be within 0.5° of the sin output. The phase of the sin output shall not exceed 6.0° ±5.0° with respect to the reference.

3.1.5.5.2 Null Voltage. With the IMU gimbal angles commanded to 0.0° ±0.01° for the sine output and 90.0° ±0.01° for the cosine output, the total null voltage shall not exceed 100 mv rms and the inphase null shall not exceed 3.0 mv rms.

3.1.5.5.3 Phasing. The sine and cosine outputs shall be in phase (0°) with the reference for gimbal angles of +45.0° and shall be out of phase (180°) for gimbal angles of +215.0°.

3.1.5.6 IMU Cage. The IMU gimbals shall drive until the resolver 1X sine signals indicate 0±0.5V rms with the IMU gimbals initially coarse aligned to 10° and with the IMU Cage discrete present at the interface. Upon removal of the IMU Cage discrete from the interface the Stable Member shall become inertial.

3.1.6 RR/CDU Control Requirements

3.1.6 1 RR CDU Zero. This mode shall be initiated by entering Verb 40, Noun 55 at the LGC DSKY.

3.1.6.1.1 LGC Counters. The RR Shaft and Trunnion Counters at locations 00054 and 00053 in the LGC shall indicate all zeros.

3.1.6.2 RR Designate Mode. This mode shall be initiated by entering Verb 41, Noun 55 at the LGC DSKY.

3.1.6.2.1 RR CDU AC D/A Nulls. The RR CDU AC D/A outputs at the interface shall not exceed 0.30 volts rms subsequent to completion of the torquing command.

3.1.6.2.2 Angular Command Accuracy. The LGC shall command +9, +6, 0, -6, -9 degree increments to the shaft and trunnion CDU DAC's. The voltage output of the RR Shaft AC D/A Error and RR Trunnion AC D/A Error shall be +4.5±0.27, +3.00±0.18, less than 0.056, -3.0±0.18, and -4.5±0.27 volts rms respectively, the minus sign indicating that the output is out of phase with respect to the reference.

3.1.6.2.2.1 RR CDU Read Ambiguity. The RR shaft and trunnion CDU's shall be capable of repeating an angle of +225.0 (-135.0) to within 1 bit.

3.1.6.2.3 Angular Tracking Accuracy. With the RR Data good and the Auto Angle Track Enable discrete present and with a simulated Shaft and Trunnion gimbal angle of 45.00°, the Shaft and Trunnion counters in the LGC shall indicate the gimbal angles within ±0.02°.

3.1.6.2.3.1 Shaft and Trunnion 1X Resolver Interface. The Shaft and Trunnion 1X sine and cosine outputs shall be 19.65±0.98 volts rms at a 1X angle of 45.000°.

3.1.6.2.3.2 Shaft and Trunnion 16X Resolver Interface. The Shaft and Trunnion 16X sine and cosine outputs shall be 3.53±0.18 volts rms at a 1X angle of 2.812°.

3.1.6.2.3.3 RR CDU Fine Error. The steady state voltage of the RR Shaft Fine Error and RR Trunnion Fine Error outputs shall not exceed 0.070 volts rms.

3.1.6.2.3.4 RR CDU Coarse Error. The steady state voltage of the RR Shaft Coarse Error and RR Trunnion Coarse Error outputs shall not exceed 0.680 volts rms.

3.1.6.2.3.5 RR CDU Fail. CDU Fail indicated by a "0" in bit 7 of Channel 30 shall occur with a difference of 1.0° ±0.1° (fine error) or 33.75° ±0.3° (coarse error) between the CDU read counter and the RR gimbal resolvers.

3.1.6.2.3.6 RR Auto-Angle Track Enable Command. A "1" in bit 14 of Channel 12 shall result in a voltage of less than 5 vdc. A "0" in bit 14 of Channel 12 shall result in a voltage of 10±1 vdc.

3.1.6.3 Velocity Meters. When the Display Inertial Data discrete is present, the Lateral and Forward velocity outputs shall be as specified when the following rates are commanded by the LGC.

Rate (fps)	CDU DC DAC Output (vdc)
0	±0.007*
+0.56	+0.014 ±10%
+1.11	+0.028 ±10%
+2.23	+0.056 ±10%
+4.46	+0.113 ±6%
+8.91	+0.226 ±6%
+17.82	+0.452 ±6%
+35.65	+0.904 ±6%
+71.31	+1.808 ±6%
+89.13	+2.258 ±3%
+142.62	+3.616 ±6%
+200.0	+5.074 ±6%
+199.48	+5.060 ±6%
-89.13	-2.258 ±3%
-200.0	-5.074 ±6%

* Noise: At DC Null; less than 5.0 mv rms at frequencies below 25 cps, 30 mv rms at frequencies above 25 cps.

3.1.7 Accelerometer Loops

3.1.7.1 PIPA Scale Factor. The PIPA scale factor in a 1g field shall be 1.000 cm/sec/pulse ±400 ppm, cm/sec/pulse.

3.1.12.2 Abort Guidance Downlink Data. The AGS Downlink Data shall be in accordance with 3.1.4.11.

3.1.13 Telemetry Interface. (To be defined)

3.2 PRODUCT CONFIGURATION

3.2.1 Drawings. The configuration of the assembly shall be in accordance with APOLLO G&N Drawing 6015000 and all drawings and engineering data referenced thereon.

3.2.2 Maximum Weight

4. QUALITY ASSURANCE PROVISIONS

4.1 PRODUCT PERFORMANCE AND CONFIGURATION REQUIREMENTS/QUALITY VERIFICATION CROSS REFERENCE INDEX

Test/Examination	Requirement	JDC Number
Standby Control	3.1.1	12615
LEM Standby Mode	3.1.1.1	12615
G&N Standby Mode (LGC STBY)	3.1.1.2	12615
G&N Standby Mode (LGC Operate)	3.1.1.3	12615
Operate Control	3.1.2	N/A
IMU Operate Delay Indication	3.1.2.1	12616
Inertial Component Temperature	3.1.2.2	12616
800 CPS Power Supply Temperature	3.1.2.3	12616
Temperature Monitor 1	3.1.2.4	12616
Calibration Module Temperature	3.1.2.5	12616
+28 VDC Operate	3.1.2.6	12616
System Power Supplies	3.1.3	12618
IMU 28V, 1%, 800 CPS Supply	3.1.3.1	12618
IMU 28V, 5%, 800 CPS Supplies (Phase A and B)	3.1.3.2	12618
ECDU +4 VDC Supply	3.1.3.3	12618
Minus 28 VDC Supply	3.1.3.4	12618
Pulse Torque Power Supply	3.1.3.5	12618
800 CPS Reference Voltage	3.1.3.6	12618
3200 CPS Suspension Power	3.1.3.7	12618
LGC +4 VDC Power Supply	3.1.3.8	12618
LGC +14 VDC Power Supply	3.1.3.9	12618
LGC +28 VDC	3.1.3.10	12618
LEM Guidance Computer	3.1.4	N/A
Operational Self-Check	3.1.4.1	12617
Keyboard Operation	3.1.4.2	12617
Display Operation	3.1.4.3	12617
LGC Commands to RCS	3.1.4.4	12621
LGC Commands to Main Engine	3.1.4.5	12621
LGC Commands to SCS	3.1.4.6	12621
LGC Discrete Inputs	3.1.4.7	12622
Landing Radar Requirements	3.1.4.8	12621
Attitude Hand Controller	3.1.4.9	12622
Telemetry Uplink	3.1.4.10	12622
Telemetry Downlink	3.1.4.11	12621
LGC Warning	3.1.4.12	12617
ISS Warning	3.1.4.13	12617

Test/Examination	Requirement	JDC Method
PGNCS Caution	3.1.4.14	12617
Altitude Meters	3.1.4.15	12621
Rendezvous Radar	3.1.4.16	12621
IMU/CDU Control Requirements	3.1.5	N/A
CDU Zero	3.1.5.1	12617/12623
Coarse Align	3.1.5.2	12617/12623
Fine Align	3.1.5.3	12617/12619/12623
FDAI Linearity	3.1.5.4	12623
Total Attitude (GASTA) Interface	3.1.5.5	12623
IMU Cage	3.1.5.6	12616
RR/CDU Control Requirements	3.1.6	N/A
RR CDU Zero	3.1.6.1	12626
RR Designate Mode	3.1.6.2	12626
Velocity Meters	3.1.6.3	12623
Accelerometer Loops	3.1.7	N/A
PIPA Scale Factor	3.1.7.1	12624
PIPA Bias	3.1.7.2	12624
Stabilization Loops	3.1.8	N/A
Step Response	3.1.8.1	12619
Gimbal Torque Level	3.1.8.2	12619
IRIG Drift Coefficients	3.1.9	N/A
NBD	3.1.9.1	12624
ADIA	3.1.9.2	12624
ADSRA	3.1.9.3	12624
IRIG Scale Factor	3.1.10	12627
System Fine Alignment Accuracy	3.1.11	12625
Abort Guidance System	3.1.12	N/A
Gimbal Angle Transmission Accuracy	3.1.12.1	12619/12623
Prime Power	4.2.1.4.1	12618
Coolant Requirements	4.2.1.4.3	12611
Rotary Table Alignment Requirements	4.2.1.10	16010/16011/16012
Test Setup	4.2.1.11	sec par 4.2.1.11

4.2 GENERAL. The contractor responsible for system assembly shall be responsible for the accomplishment of each test required.

4.2.1 Test Conditions

4.2.1.1 Environmental. Unless otherwise specified, the system shall be tested under the following ambient conditions:

a. Temperature: 75° ±10°F
b. Relative Humidity: 90 percent max
c. Barometric Pressure: Ambient

4.2.1.2 Prior Compliance. Prior to system testing, assembly level and subsystem testing and inspection shall have been accomplished in accordance with ATP6015497 (ISS Subsystem) and PS2003101 (LGC Group).

4.2.1.3 Output Loading. The output loading required during testing shall be as specified in Table II.

TABLE II

OUTPUT LOADING

SIGNAL		LOAD (ohms)
FDAI	IG AC D/A Error	20K ±5%, 0° ±5°
	MG AC D/A Error	20K ±5%, 0° ±5°
	OG AC D/A Error	20K ±5%, 0° ±5°
	800 cps, 28V, 1% Ref	To be defined
GASTA (TOTAL ATTITUDE)	Sin AIG 1X	415 ±15% +j 1950 ±10%
	Cos AIG 1X	↕
	Sin AMG 1X	
	Cos AMG 1X	
	Sin AOG 1X	
	Cos AOG 1X	415 ±15% +j 1950 ±10%
ABORT GUIDANCE SECTION	+1G Delta Theta Abort	500 ±10%
	-1G Delta Theta Abort	↕
	+MG Delta Theta Abort	
	-MG Delta Theta Abort	
	+OG Delta Theta Abort	
	-OG Delta Theta Abort	
	CDU Zero	
	AGS Initialization (DNLK Data)	500 ±10%
CAUTION AND WARNING	LGC (Warning)	2.5K ±10% (lamp)
	PGNS (Caution)	
	ISS (Warning)	
ALTITUDE METERS	Altitude Meter 1	200 ±10%
	Altitude Meter 0	↕
	Altitude Rate Meter 1	
	Altitude Rate Meter 0	200 ±10%
VELOCITY METERS	Lateral Velocity	100K ±5%
	Forward Meter	100K ±5%

TABLE II (Continued)

SIGNAL		LOAD (ohms)
RENDEZVOUS RADAR	RR Shaft AC D/A Error	20±1K
	RR Trunnion AC D/A Error	20±1K
	Range Gate Strobe	200 ±10%
	Range Rate Gate Strobe	200 ±10%
	Counter Readout Comm	200 ±10%
	Radar Reset Strobe	200 ±10%
LANDING RADAR	XA Velocity Gate Strobe	200 ±10%
	YA Velocity Gate Strobe	↕
	ZA Velocity Gate Strobe	↕
	Range Gate Strobe	↕
	Counter Readout Comm	↕
	Radar Gate Reset Strobe	200 ±10%
MASTER CLOCK AND TELEMETRY	1024K pps Clock	500 ±10%
	DLNK Data	100 ±10%

4.2.1.4 Inputs. The system shall perform as specified herein with the following inputs.

4.2.1.4.1 Prime Power. The system prime power shall be as specified in Table III.

TABLE III

SYSTEM PRIME INPUT POWER

VOLTAGE*	IDENTIFICATION
+28.0 +5.5, -6 vdc	+28 VDC IMU Standby
+28.0 +5.5, -3.5 vdc	+28 VDC IMU Operate
+28.0 +5.5, -3.5 vdc	+28 VDC LGC
+28.0 +5.5, -3.5 vdc	AOT Heater
115.0±2.5V rms, 400±10 cps	Illumination
2 to 5.5 vdc	Variable Caution Light
2 to 5.5 vdc	Variable Status Light
0 to 75V rms	Variable DSKY
400±10 cps	Illumination
* Values are steady state only	

4.2.1.4.2 Signals. The system input signals shall be as specified in Table IV.

TABLE IV

SYSTEM INPUT SIGNALS

SIGNAL	EXCITATION CHARACTERISTICS
Abort Abort Stage Engine Armed Display Inertial Data Att Control Out of Det Att Hold Mode Stage Verify Auto Throttle Auto Stabilization Thruster pr 4D/4S Fail Thruster pr 3U/3S Fail Thruster pr 4U/4F Fail Thruster pr 3D/3F Fail Thruster pr 1D/1S Fail Thruster pr 1U/1F Fail Thruster pr 2U/2S Fail Thruster pr 2D/2F Fail G&N Control of S/C (Digital Auto Pilot in Control) +EL (LPD) +PMI -EL (LPD) -PMI +AZ (LPD) +RMI -AZ (LPD) -RMI +YMI -YMI +X Trans Comm (Man) -X Trans Comm (Man) +Y Trans Comm (Man) -Y Trans Comm (Man) +Z Trans Comm (Man) -Z Trans Comm (Man) Rate of Descent (+) Rate of Descent (-) Rate of Descent Reset IMU Cage Command Pitch Gimbal Off Roll Gimbal Off LR Range Data Good LR Position 1 (Desc) LR Position 2 (Hover) LR Vel Data Good LR Range Lo Scale RR Data Good RR Range Lo Scale RR PWR ON & in Auto LGC Mode	Switch ON: 17.5±0.5 vdc Switch OFF: 0±2 vdc
Prop Pitch Rate Cmd Prop Roll Rate Cmd Prop Yaw Rate Cmd	See 4.2.1.4.2.1

TABLE IV (Continued)

SIGNAL	EXCITATION CHARACTERISTICS
L Rdr In 0 L Rdr In 1 R Rdr In 0 R Rdr In 1	See 4.2.1.4.2.2
RR Shaft Sin 16X RR Shaft Cos 16X RR Trunnion Sin 16X RR Trunnion Cos 16X	See 4.2.1.4.2.3
RR Shaft Sin 1X RR Shaft Cos 1X RR Trunnion Sin 1X RR Trunnion Cos 1X	See 4.2.1.4.2.4
Dink Start Dink End Dink Sync	See 4.2.1.4.2.5.1
Uplnk "0" Uplnk "1"	See 4.2.1.4.2.5.2
ACE Bias 1 ACE Bias 2	See 4.2.1.4.2.6
Inhibit Power Fail	28.0±4.5 vdc
LR Antenna Pos #1 Auto Angle Track Enable RCS Jet 4D RCS Jet 3D RCS Jet 2D RCS Jet 1D RCS Jet 3U RCS Jet 2U RCS Jet 4U RCS Jet 1U RCS Jet 2S RCS Jet 1S RCS Jet 3S RCS Jet 2F RCS Jet 3F RCS Jet 4F RCS Jet 1F Engine On Asc or Desc Engine Off Asc or Desc + Pitch Trim - Pitch Trim + Roll Trim - Roll Trim	10±1 vdc through a resistive impedance of 2K ±10% ohms ▲ ▼ 10±1 vdc through a resistive impedance of 2K ±10% ohms

4.2.1.4.2.1 Attitude Hand Controller. The excitation shall provide the following signal characteristics:

a. Null Voltage: 30 mv rms max
b. Quadrature: 10 mv rms max
c. Voltage Range: 0 to 2.80±0.14V rms
d. Source impedance: 2K ohms at 85°
e. Excitation: 28V, 800 cps, 5 percent, from the system
f. Maximum Phase Shift: 10°
g. An inphase output represents a positive rate command
h. Linearity: 5 percent

4.2.1.4.2.2 Radar Data Pulse Characteristics. The excitation shall provide the following signal characteristics:

a. Amplitude (A): 7±3V
b. Pulse Width at A/2 Point: 4±2 microsec
c. Droop: 20 percent max of A at 2 microsec
d. Maximum Backswing: 4V
e. Risetime: 0.20 microsec max from 10 percent to 90 percent of A
f. Repetition Rate: 3.2K pps
g. Timing: Read Out Sync pulse shall lead either data pulses by a maximum of 1 microsecond determined at the respective A/2 points.

4.2.1.4.2.3 RR 16X Resolver Sin and Cosine (Shaft and Trunnion)

a. Sense: Positive angle rotation – sine and cosine voltages shall be inphase with the reference voltage for the first 90 electrical degrees of resolver rotation.

b. Zero: Resolver electrical zero corresponds to shaft and trunnion zero angle position. The electrical zero occurs when the sine signal is at null and the cosine signal is at maximum and inphase with the reference excitation signal. The 16X resolver shall be the primary alignment reference index for both shaft and trunnion. The electrical reference zero of the 16X and 1X outputs of each resolver shall coincide within 5 arc minutes of the mechanical shaft angle.

c. Output Form

(1) Sin: $e_{16s} = E_3 \sqrt{2} \sin(16A) \sin(2\pi ft + \phi_3)$

(2) Cosine: $e_{16c} = E_4 \sqrt{2} \cos(16A) \sin(2\pi ft + \phi_4)$

Where:

$E_3 = E_4 = 5V$ rms ±5 percent (output voltage)

A = Antenna gimbal angle
f = Ref frequency (800 cps ±0.5 percent)
t = Time
ϕ_3 and ϕ_4 = phase shift (11° ±5° with respect to the ref voltage)

d. Nulls at any position: 10 mv rms in phase max

e. Maximum DC Source Impedance: 200 ohms - each winding

4.2.1.4.2.4 RR 1X Resolver Sine and Cosine (Shaft and Trunnion)

a. Sense: Positive angle rotation - sine and cosine voltages shall be inphase with the reference voltage for the first 90 electrical degrees of resolver rotation.

b. Zero: Resolver electrical zero corresponds to shaft and trunnion zero angle position. The electrical zero occurs when the sine signal goes to null and the cosine signal is near maximum and inphase with the reference excitation signal.

c. Output Form:

(1) Sine: $e_{1s} = E_1 \sqrt{2} \text{ Sin (A) Sin } (2\pi ft + \phi_1)$

(2) Cos: $e_{1c} = E_2 \sqrt{2} \text{ Cos (A) Sin } (2\pi ft + \phi_2)$

Where:

$E_1 = E_2 = 28V$ rms ±5 percent

A = Antenna angle

f = Ref Frequency (800 cps ±0.5 percent)

t = Time

ϕ_1 and ϕ_2 = phase shift (5° ±3° with respect to ref voltage)

d. Maximum DC Source Impedance: 300 ohms each winding

4.2.1.4.2.5 LGC Pulse Inputs. The excitation shall provide signal characteristics as follows:

4.2.1.4.2.5.1 Downlink Interface

a. Maximum Source Impedance: 100 ohms
b. Amplitude (A): 4.5±1.0V
c. Pulse Width at A/2 Point: 4±1 microsec
d. Backswing: 0
e. Risetime: 0.3 microsec max. from 10 percent to 90 percent of A
f. Repetition Rate: 50 pps (except sync pulse - 2K pps at 51.2 kc: 40 pulses 50 times per sec.)

g. Timing: (ref to A/2 point) leading edge:

(1) Start to bit sync: 19.5±5.0 μsec
(2) Bit sync to data: 1 μsec max
(3) Stop pulse: 19.5±5.0 μsec after last sync pulse
(4) There shall be 40-bit sync pulses between each start and stop pulse

4.2.1.4.2.5.2 Uplink Interface (UPLINK "0" and UPLINK "1"):

a. Source Impedance: 100 ohms -1; 10 ohms -0 max.
b. Amplitude (A): 7±3V
c. Pulse Width at A/2 Point: 3±1 μsec
d. Droop: 20 percent at 2 μsec
e. Maximum Backswing: 4V
f. Risetime: 0.2 μsec max. from 10 percent to 90 percent of A
g. Repetition Rate: 1K pps
h. Maximum Noise: No pulse - ±0.4V

4.2.1.4.2.6 ACE Bias 1 and 2. A switchable ground shall be supplied to each interface.

4.2.1.4.3 Coolant Requirements

4.2.1.4.3.1 IMU. The IMU shall be provided with water-glycol coolant at a temperature of 40° ±3°F and flow rate of 33±5 lb per hour.

4.2.1.4.3.2 PSA, CDU, PTA Headers. The PSA, CDU, and PTA cold plates shall be provided with coolant sufficient to maintain the header temperature below 70°F.

4.2.1.4.4 Inertial Component Temperature Sensor Current:

a. PIPA 6±0.12 ma dc
b. IRIG 2±0.04 ma dc

4.2.1.5 Test Data. All system test data shall be recorded on suitable reproducible forms and stored at the contractor's facility. Copies of the recorded data shall accompany the system. Where space is provided to indicate the value or specific reading obtained, the specific reading shall be recorded if a limit or limits is given for a test. Further, the initials of the individual performing the inspection shall be inserted above the value observed and recorded. If limits are not stated, it is required that the individual performing the test initial in the space provided indicating that the requirements were met.

4.2.1.6 Test Values. All test values given in Section 4 of this specification reflect allowances for instrumentation error, loads, or variation in supply voltages and frequencies.

4.2.1.7 Safety Precautions. Normal safety precautions required during testing of precision electromechanical equipment shall be followed. The following requirements shall apply upon loss of the 28 vdc to the G&N System 3200 cps power supply.

4.2.1.7.1 Component Temperature. The temperature of the inertial components shall be maintained between the following limits. If these limits are exceeded, the inertial components may be recalibrated.

a. IRIG: 120°F and 150°F
b. PIP: 115°F and 145°F

4.2.1.7.2 Suspension Power

a. The 3200 cps suspension power shall not be off while torquing of the inertial components is taking place. If this requirements is not complied with the inertial components shall be degaussed and recalibrated.

b. The 2V, 3200 cps suspension power shall be maintained for a minimum of 3 minutes prior to pulse torquing. Suspension power shall be maintained a minimum of 1 hour prior to any inertial component parameter determination.

4.2.1.7.3 Gimbal Lock. A VERB 36 shall never be entered into the DSKY with the GIMBAL LOCK lamp illuminated.

4.2.1.8 Test Equipment Required. The test equipment utilized in whole or part as required by the respective JDC for the test being conducted shall be in accordance with Drawing 1900030.

4.2.1.9 Jigs and Fixtures. Test probes shall not be used to make direct electrical connections to connectors of the Apollo Guidance Equipment. Jigs made up of mating connectors shall be used.

4.2.1.10 Rotary Table Alignment Requirements. The Rotary Table Tilt axis shall be aligned parallel to true east within ±1 minute, and at 0° tilt the rotary axis shall be aligned within ±2 seconds of vertical.

4.2.1.10.1 Fixture Alignment and Calibration Procedures. The procedures shall be conducted in accordance with the following JDC's.

JDC 16010	Rotary Table Leveling Calibration Test
JDC 16011	IMU Mounting Fixture Alignment Test about the X and Y Axes
JDC 16012	IMU Mounting Fixture Alignment Test about the Z axis

The rotary axis and tilt axis calibrations shall be accomplished at 3-month intervals, in accordance with the following JDC's.

JDC 19728	Rotary Table Tilt and Rotary Axis Calibration

4.2.1.11 Test Setup. The APOLLO G&N equipment shall be tested and inspected under the test conditions specified herein.

4.2.1.11.1 Assembly Requirements. The G&N System shall be assembled to the G&N Ground Support Equipment and the assembly and test equipment interconnect procedures shall be conducted in accordance with the following JDC's:

JDC	DESCRIPTION
12600	LEM G&N System Visual Inspection
12601	LGC Installation
12602	Computer Control and Reticle Dimmer Assembly Installation
12603	"A" Harness Installation
12604	LGC Buffer Assembly Installation
12605	DSKY Installation
12606	"B" Harness Installation
12608	LEM G&N System Passive Test
12610	Coolant Hose Connection
12611	G&N Coolant Supply Turnon-TurnOff
16009	IMU & PTA Mounting Fixture Installation on the Rotary Table
16013	Installation of the IMU on the IMU Mounting Fixture
16014	Installation of the pulse torquing Assembly to the PTA Holding Fixture Assembly on the Rotary Table
16017	CDU Installation
16018	PSA Installation

4.2.1.12 Test Sequence. The sequence of operations shall be as specified in Figure 2.

4.2.2 Nonconforming Units. Failure of the system to pass any examination or test of this specification shall automatically classify the unit as nonconforming. Each nonconforming unit corrected shall be reinspected. Reinspection may be limited to the test or examination which defined the nonconformance, or, when directed by the cognizant inspector, a complete retest and reexamination may be required. Nonconforming units which have not been corrected will be considered for acceptance only upon formal application by the contractor to the cognizant NASA representative.

4.3. TESTS

4.3.1 Applicable JDC's. The JDC's specified in the index of 4.1 form the acceptance test procedures of this specification.

TEST PROCEDURE FLOWGRAM

FIGURE 2

5. PREPARATION FOR DELIVERY

5.1 GENERAL. With the exception of the IMU, preparation for delivery shall be in accordance with Specification ND1002214.

5.2 IMU Preparation for Shipment. The Inertial Measurement Unit shall be prepared for shipment in accordance with JDC12699, Post-Test Preparation of IMU for Shipment.

6. NOTES. (To be supplied)

6.1 DEFINITIONS AND ABBREVIATIONS

APOLLO G&N Specification
PS6015000 REV B
Original Issue Date:
Release Authority: TDRR 2534
Class A Release
CODE IDENT NO. 80230

MASTER END ITEM DETAIL SPECIFICATION

PART II

PRODUCT CONFIGURATION AND ACCEPTANCE TEST REQUIREMENTS

PGNCS SPACECRAFT EQUIPMENT

LEM

DRAWING NO. 6015000

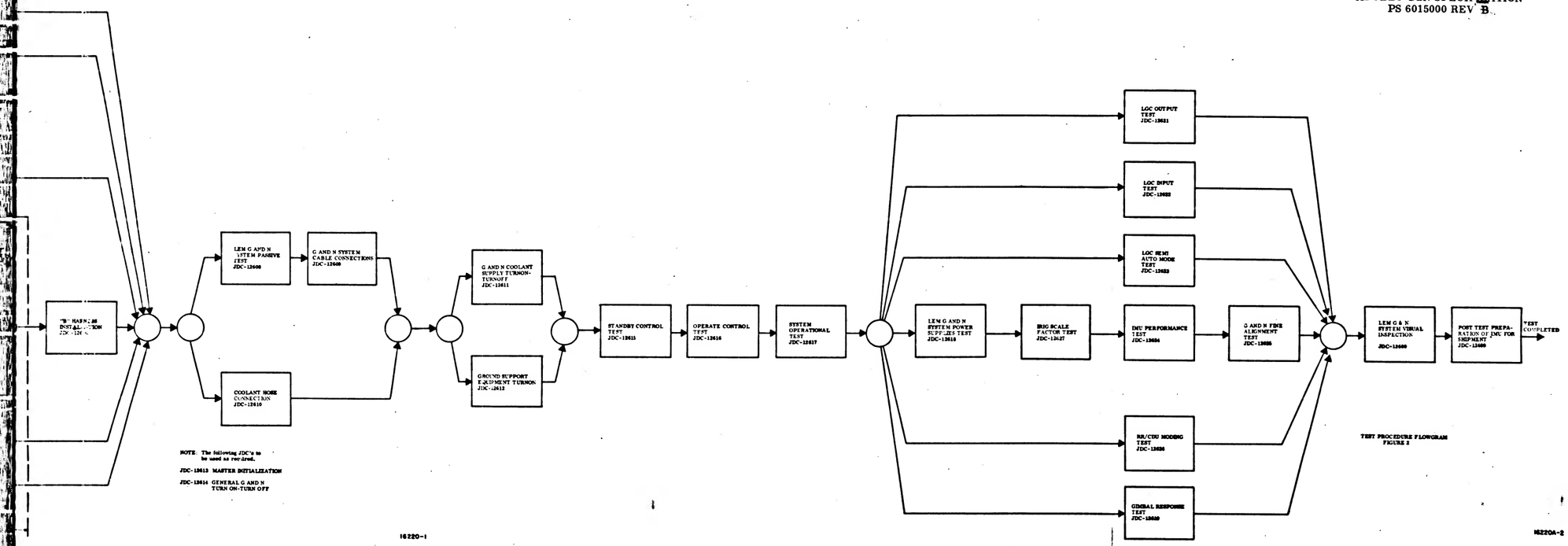
MEI NO. 6015000

Record of Revisions

Date	Revision Letter	TDRR No.	Pages Revised	Approvals	
				MIT	NASA
3/16/66	A	27208	4, 6-33 now 34 pages was 33.	WK	TM
3/15/66	B	27091	33	WK	TM

This specification consists of page 1 to 34 inclusive.

APPROVALS	NASA/MSC	MIT/IL	ACSP



NOTE: The following JDC's to be used as required.

JDC-12613 MASTER INITIALIZATION

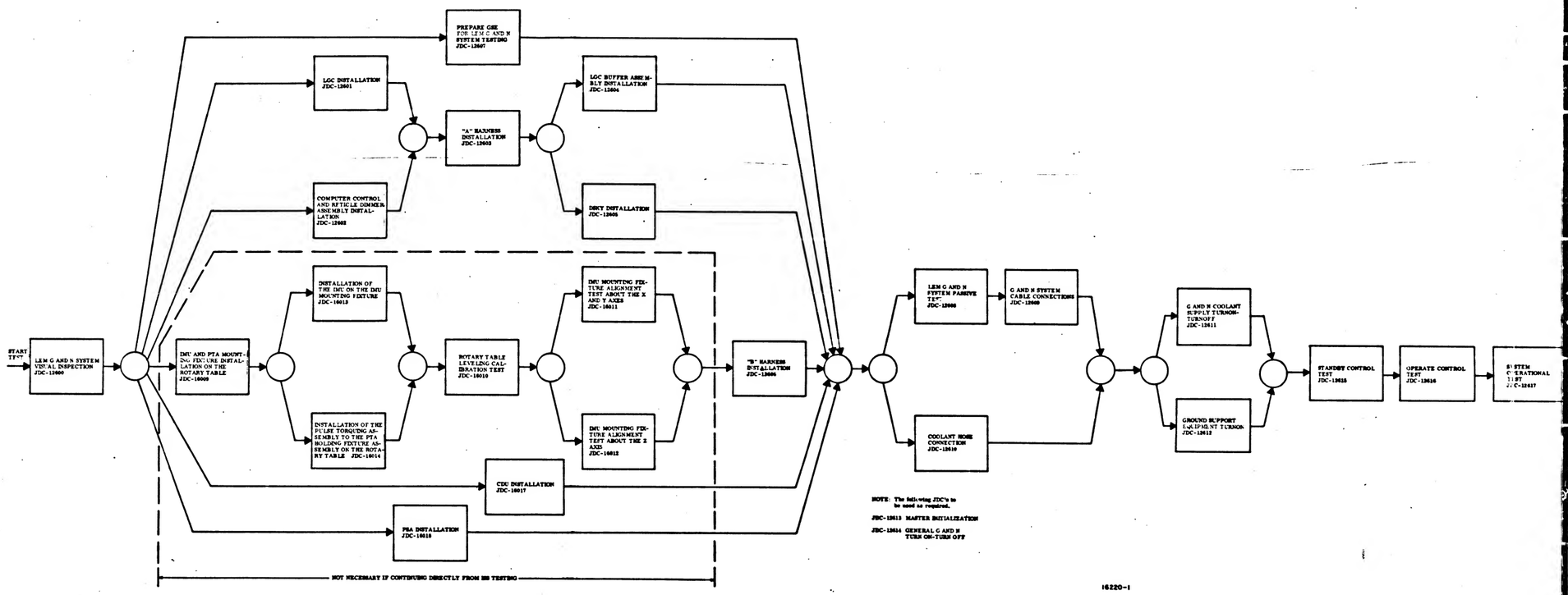
JDC-12614 GENERAL G AND N TURN ON-TURN OFF

16220-1

TEST PROCEDURE FLOWGRAM FIGURE 2

16220A-2

Test Procedure Flowgram
Figure 2


START TEST
LEM G AND N SYSTEM VISUAL INSPECTION JDC-12000
PREPARE GSE FOR LEM C AND N SYSTEM TESTING JDC-12007
LGC INSTALLATION JDC-12001
"A" HARNESS INSTALLATION JDC-12002
COMPUTER CONTROL AND RETICLE DIMMER ASSEMBLY INSTALLATION JDC-12002
LGC BUFFER ASSEMBLY INSTALLATION JDC-12004
DSKY INSTALLATION JDC-12005
DMU AND PTA MOUNTING FIXTURE INSTALLATION ON THE ROTARY TABLE JDC-16009
INSTALLATION OF THE DMU ON THE DMU MOUNTING FIXTURE JDC-16013
INSTALLATION OF THE PULSE TORQUING ASSEMBLY TO THE PTA HOLDING FIXTURE ASSEMBLY ON THE ROTARY TABLE JDC-16014
ROTARY TABLE LEVELING CALIBRATION TEST JDC-16010
DMU MOUNTING FIXTURE ALIGNMENT TEST ABOUT THE X AND Y AXES JDC-16011
DMU MOUNTING FIXTURE ALIGNMENT TEST ABOUT THE Z AXIS JDC-16012
CDU INSTALLATION JDC-16017
PSA INSTALLATION JDC-16018
"B" HARNESS INSTALLATION JDC-12006
LEM G AND N SYSTEM PASSIVE TEST JDC-12008
G AND N SYSTEM CABLE CONNECTIONS JDC-12009
COOLANT HOSE CONNECTION JDC-12010
G AND N COOLANT SUPPLY TURNON-TURNOFF JDC-12011
GROUND SUPPORT EQUIPMENT TURNON JDC-12012
STANDBY CONTROL TEST JDC-12015
OPERATE CONTROL TEST JDC-12016
SYSTEM OPERATIONAL TEST JDC-12017
NOT NECESSARY IF CONTINUING DIRECTLY FROM HB TESTING
NOTE: The following JDC's to be used as required.
JDC-12013 MASTER INITIALIZATION
JDC-12014 GENERAL G AND N TURN ON-TURN OFF
16220-1

APOLLO G&N Specification
PS6015000 REV C
Original Issue Date:
Release Authority: TDRR 2534
Class A Release
CODE IDENT NO. 80230

MASTER END ITEM DETAIL SPECIFICATION

PART II

PRODUCT CONFIGURATION AND ACCEPTANCE TEST REQUIREMENTS

PGNCS SPACECRAFT EQUIPMENT

LEM

DRAWING NO. 6015000

MEI NO. 6015000

Record of Revisions

Date	Revision Letter	TDRR No.	Pages Revised	Approvals MIT	Approvals NASA
3/16/66	A	27208	4, 6-33 now 34 pages was 33.	WK	TM
3/15/66	B	27091	33	WK	TM
6/28/66	C	29846	4, 6, 7, 8, 11, 13, 15, 17, 18, 23, 30, 31, 32	MGM	ACM

This specification consists of page 1 to 34 inclusive.

APPROVALS	NASA/MSC	MIT/IL	MIT/IL	MIT/IL	ACSP

3. REQUIREMENTS

3.1 PERFORMANCE

3.1.1 Standby Control

3.1.1.1 LEM Standby Mode. The following requirements shall be met with the IMU in the standby condition.

3.1.1.1.1 28 VDC IMU Standby. The IMU Standby voltage shall be 22.0±1.0 vdc.

3.1.1.1.2 Inertial Component Temperature. The mean stabilized PIPA temperature shall be 130.5±1.5°F within 1 hour after entering the Standby Mode. The mean stabilized IRIG temperature shall be within 2.0°F of the PIPA temperature.

3.1.1.2 G&N Standby Mode (LGC STBY). The following requirements shall be met with the IMU in the standby condition and the LGC in the standby condition.

3.1.1.2.1 28 VDC IMU Standby. The IMU Standby voltage shall be 28.0±1.0 vdc.

3.1.1.2.2 3200 cps Suspension Power. The 3200 cps suspension voltage shall be 28.6±0.56 volts rms at a frequency of 3200±1 cps.

3.1.1.2.3 Master Clock Sync. The Master Clock Sync signal characteristics shall be as follows. (See Figure 1).

a. Amplitude: 4.0 volts minimum.
b. Pulse Width: 0.50±0.25 microseconds.
c. Rise Time: 0.2 microseconds max. from 10 to 90 percent of amplitude.
d. Frequency: 1024K pps ±2 ppm over a 15 minute period.

3.1.1.3 G&N Standby Mode(LGC Operate). The following requirements shall be met with the IMU in the standby condition, the LGC in the operate condition, and the LGC +4 and +14 volt dc power supplies at 4.0±0.15 and 14.0±0.2, respectively.

3.1.1.3.1 LGC Voltage Fail Alarm. A Voltage Fail alarm shall occur as indicated by the presence of a LGC Warning discrete, when the power supply outputs are individually or concurrently at the following outputs:

	+4 VDC Supply	+14 VDC Supply
a.	+3.6±0.5 vdc	+12.6±0.2 vdc
b.	+3.6±0.5 vdc	+16.2±0.2 vdc
c.	+4.5±0.2 vdc	+16.2±0.2 vdc
d.	+4.5±0.2 vdc	+12.6±0.2 vdc

3.1.1.3.2 LGC Operating Margin. The LGC shall exhibit no failures with the Inhibit Power Fail discrete present and the +4 vdc and +14 vdc power supplies concurrently at the value specified in paragraph 3.1.1.3.1.

3.1.1.4 Reticle Lamp Voltage. The variable AOT Reticle Lamp Voltage shall have the following characteristics at the interface:

a. Minimum Voltage: less than -0.27 vdc
b. Maximum Voltage: -4.67 vdc

3.1.2 Operate Control

3.1.2.1 IMU Operate Delay Indication. LGC Channel 30 shall indicate a "0" in bit 14 when the system is supplied with the +28.0±0.5 VDC IMU Operate power and shall remain in the "0" state for 90±5 seconds, after which time bit 14 of Channel 30 and bit 15 of Channel 12 shall indicate a "1".

3.1.2.1.1 Inertial Component Pulse Torquing. During the 90 second delay period, the IRIG and PIPA pulse torque power supply shall be inhibited. Loss of +28 VDC LGC prime power shall result in the same condition.

3.1.2.1.2 Automatic Caging and CDU Ambiguity Operation. The IMU gimbal resolvers shall drive until the 1X sine signals indicate 0.00±0.50 volts rms and the 1X cosine signals indicate 26.0±2.6 volts rms, with the IMU gimbal angles initially at 225°.

3.1.2.2 Inertial Component Temperature. The following requirements shall be met in the Operate mode with IMU gimbal angles of 0° ±5°.

3.1.2.2.1 Standby to Operate Transient. The mean stabilized PIPA temperature in the Operate mode shall be within 0.50°F of the mean stabilized PIPA temperature in the Standby mode.

3.1.2.2.1.1 Standby to Operate Transient Time. The PIPA temperature 15 minutes after switching from the Standby to Operate mode shall be within 0.5°F of the mean stabilized Operate mode PIPA temperature. The IRIG temperature 30 minutes after switching from the Standby to Operate mode shall be within 0.5°F of the mean stabilized Operate mode IRIG temperature.

3.1.2.2.2 Inertial Component Temperature Control Point. The mean stabilized temperature of the PIPA and IRIG components shall be within 130.5±1.5°F and 135±2.5°F respectively. The PIPA and IRIG temperature are stabilized when they have not changed by more than 0.1°F over a one hour period.

3.1.2.2.3 Heater Telemetry Discrete. The Heater Telemetry Discrete shall cycle ON and OFF. The ON state shall be 26.5±7 vdc at the interface.

3.1.2.2.4 Blower Telemetry Discrete. The Blower Telemetry Discrete shall remain in the ON state and shall be 28.0±1.4V rms at the interface.

3.1.2.3 800 CPS Power Supply Temperature. The resistance of the temperature thermistor shall be 1.715K to 8.37K ohms.

3.1.2.4 Temperature Monitor 1. The resistance of the temperature thermistor shall be 1.4K to 13.25K ohms.

3.1.2.5 Calibration Module Temperature. The resistance of the temperature thermistor shall be 2.8K to 13.25K ohms.

3.1.2.6 +28 VDC IMU Operate. The IMU Operate voltage shall be 28.5+0, -1 vdc.

3.1.3 System Power Supplies. The system power supplies shall meet the following requirements.

3.1.3.1 IMU 28V, 1 Percent, 800 CPS Supply.

3.1.3.1.1 Voltage. The output voltage shall be 28.00±0.56V rms.

3.1.3.1.2 Frequency. The output frequency shall be 800±1 cps.

3.1.3.2 IMU 28V, 5 Percent, 800 CPS Supplies (Phases A and B)

3.1.3.2.1 Voltage. The output voltage of phase A shall be 28.0±1.4V rms and the output voltage of phase B shall be 28.0±2.1V rms.

3.1.3.2.2 Frequency. The frequency of the power supply outputs shall be 800±1 cps.

3.1.3.2.3 Phase. The output of the phase A supply shall be -90° ±10° with respect to the IMU 28V, 1 percent power supply output. The output of the phase B supply shall be -90° ±10° with respect to the IMU 28V, 5 percent, phase A power supply output.

3.1.3.3 ECDU +4 VDC Supply. The ECDU +4 vdc supply output voltage shall be +4.0±0.2 vdc.

3.1.3.4 Minus 28 VDC Supply. The -28 vdc supply output voltage shall be -27.5±6.0 vdc.

3.1.3.5 Pulse Torque Power Supply. The pulse torque power supply outputs shall be as follows at the interface.

	OUTPUT	VOLTAGE
a.	120 vdc (1)	120±6 vdc
b.	28 vdc (PVR) (3)	28.0±1.4 vdc

3.1.3.6 800 CPS Reference Voltage. The reference voltage at the interface shall have the following characteristics.

3.1.3.6.1 Amplitude. The amplitude shall be 28.00V rms ±2 percent.

3.1.3.6.2 Frequency. The frequency shall be 800±1 cps.

3.1.3.6.3 Instantaneous Voltage. The amplitude shall not exceed 45V rms and shall return to 28.0±2.0 percent within 5 seconds after application of 28 VDC IMU Operate power.

3.1.3.7 3200 CPS Suspension Power. The 3200 cps suspension power supply shall have the following characteristics with the LGC in Standby or Operate.

3.1.3.7.1 Voltage. The Feedback voltage of the 3200 cps supply shall be 28.60±0.56V rms.

3.1.3.7.2 Frequency. The frequency shall be 3200±1 cps.

3.1.3.7.3 Phase. The phase angle of the 3200 cps supply shall be at 0° ±10° with respect to the 3200 pps synchronizing pulse train.

3.1.3.8 LGC +4 VDC Power Supply. The output voltage of the LGC +4 vdc power supply shall be +4.00±0.15 vdc.

3.1.3.8.1 Noise. The peak-to-peak noise level shall be 0.4 volt or less.

3.1.3.8.2 ACE Bias 1. The +4 vdc power supply output shall drop by 0.70±0.30 vdc with the requirements of 4.2.1.4.2.6 met.

3.1.3.9 LGC +14 VDC Power Supply. The output voltage of the LGC +14 vdc power supply shall be +14.00±0.20 vdc.

3.1.3.9.1 Noise. The peak-to-peak noise level shall be 0.4 volt or less.

3.1.3.9.2 ACE Bias 2. The +14 vdc power supply output shall drop by 3±2 vdc with the requirements of 4.2.1.4.2.6 met.

Channel 6	Bit No.	Channel 6	Bit No.
+Y RCS Jet 2S	5	+Z RCS Jet 3F	1
+Y RCS Jet 1S	8	+Z RCS Jet 2F	4
-Y RCS Jet 4S	7	-Z RCS Jet 4F	2
-Y RCS Jet 3S	6	-Z RCS Jet 1F	3

3.1.4.5 LGC Commands to Main Engine. The interface shall exhibit the following pulse characteristics upon command from the LGC.

a. Increase Throttle Rate Descent Engine
b. Decrease Throttle Rate Descent Engine

3.1.4.5.1 Pulse Characteristics (See Figure 1)

a. Amplitude (A): 7±3V
b. Width at A/2 Point: 3±1 μsec
c. Droop: 20 percent at 2 μsec from A peak
d. Backswing: 4 volts peak with respect to the amplitude reference level
e. Risetime: 0.2 μsec max (10 percent to 90 percent of A)
f. Frequency 3.2K pps ±1 pps
g. Max Noise: +0.4 to -4.0 volts with respect to the amplitude reference level.

3.1.4.6 LGC Commands to Stabilization Control System. The following interface shall exhibit 2 to 5 vdc for a logic 1, or 10±1 vdc for a logic 0, command to the specified bit assignments of LGC CH 11 and CH 12.

Interface	Bit	Channel
Engine On Asc or Desc	13	11
Engine Off Asc or Desc	14	11
+Pitch Gimbal Trim	9	12
-Pitch Gimbal Trim	10	12
+Roll Gimbal Trim	11	12
-Roll Gimbal Trim	12	12

3.1.4.7 LGC Discrete Inputs. Each interface specified below, when excited in accordance with the appropriate voltage specified in 4.2.1.4.2, shall cause the proper bit states as specified in Table I.

3.1.4.12 LGC Warning. The LGC Warning discrete shall occur as a result of repeated or prolonged occurrances of the following conditions:

a. VOLTAGE FAIL (in standby mode)

b. LIGHT TEST

3.1.4.13 ISS Warning. The ISS Warning discrete shall occur as a result of a "1" in bit 1 of CH 11.

3.1.4.14 PGNS Caution. The PGNS Caution discrete shall occur as a result of any or all of the following conditions:

a. Program Caution: a "1" in bit 9 of RLYWD 1100
b. Temperature: a "1" in bit 4 of CH 11
c. Gimbal Lock: a "1" in bit 6 of RLYWD 1100
d. Tracker: a "1" in bit 8 of RLYWD 1100
e. RESTART

3.1.4.15 Altitude Meters. The LGC shall command known data words, Altitude "0", Altitude "1", Altitude Rate "0", and Altitude Rate "1". The pulse characteristics of the data words shall be as follows:

a. Amplitude (A): 7±3V
b. Pulse Width at A/2 Point: 3±1 microsec
c. Droop: 20 percent of A at 2 microsec
d. Maximum Backswing: 4V
e. Risetime: 0.2 microsec max from 10 percent to 90 percent of A
f. Frequency: 3.2K pps±1 pps.

3.1.4.16 Rendezvous Radar (RR). The RR Read Cycle shall be commanded by LGC program. The Read Cycle shall consist of a constant 3200 cycle pulse train output (RR Gate Reset Strobe) in conjunction with one of two Gate Strobe (Range or Range Rate) outputs. Subsequent to issuance of the Gate Strobe, the Read Out Sync burst shall be commanded. Each Gate Strobe shall be commanded in conjunction with the Reset Strobe and Read Out Sync burst and shall appear at the interface.

3.1.4.16.1 Pulse Characteristics and Data Acquisition. Under the conditions of 3.1.4.16, and with the RR Data Good discrete present at the LGC interface as demonstrated by a "1" in bit 4 of CH 33, the following pulse and data acquisition characteristics shall exist.

3.1.4.16.1.1 Pulse Characteristics. The pulse characteristics of the pulse signals specified in 3.1.4.16 shall be as follows. (See Figure 1 for the wave shape requirements.)

3.1.5.2.2 AC D/A Command. The IMU CDU AC D/A output at the interface shall not exceed 0.30V rms subsequent to completion of torquing command.

3.1.5.2.3 Torquing Rate. The CDU, when stimulated by the maximum LGC torquing command, shall exhibit an average gimbal torquing rate of 16±2 degrees per second over a minimum range of 67.5 degrees.

3.1.5.3 Fine Align. The mode shall be initiated by entering Verb 42 at the LGC DSKY.

3.1.5.3.1 CDU Read Repeatability Accuracy. The LGC shall be capable of repeating given IG and OG angles in each quadrant to within ±3 bits. The same repeating accuracy shall be met for MG angles of less than ±70.0 degrees.

3 1.5.3.1.1 CDU Read Ambiguity. The IG and OG CDU's shall be capable of repeating an angle of 225 (-135) ±2 degrees to within 3 bits.

3.1.5.3.2 CDU Fine Error. The dynamic error at the interface shall not exceed 0.070 volts rms through out a range of 22.5 degrees of IMU gimbal rotation.

3.1.5.3.3 CDU Coarse Error. The dynamic error at the interface shall not exceed 0.680 volts rms through an inner and outer IMU gimbal rotation of 360° and a middle gimbal rotation of ±67.5°.

3.1.5.3.4 IMU CDU Fail. CDU Fail indicated by a "0" in bit 12 of CH 30 shall occur with a difference of 1.0° ±0.1° (fine error) or 33.75° ±0.3° (coarse error) between the CDU read counter and the IMU gimbal resolvers.

3.1.5.4 FDAI Linearity. The LGC shall command the following angular increments to each CDU resulting in the voltage and phase outputs as specified at the interface.

Increment (deg)	CDU A/C DAC Error (volts)	Phase wrt ref)
+17	+5.05 ±10%	in
+16	+4.86 ±10%	in
+6	+1.8 ±10%	less than 8° shift
0	0.056 max	N/A
-6	-1.8 ±10%	out
-16	-4.86 ±10%	out
-17	-5.05 ±10%	out

3.1.5.5 Total Attitude (GASTA) Interface. With the IMU gimbal angles at 45.0° the output at the interface shall be 18.4±1.84V.

a. Cos AIG 1X
b. Sin AIG 1X

c. Cos AMG 1X
d. Sin AMG 1X
e. Cos AOG 1X
f. Sin AOG 1X

3.1.5.5.1 Phase Shift. The phase of the cosine output shall be within 0.5° of the sin output. The phase of the sin output shall not exceed 6.0° ±5.0° with respect to the reference.

3.1.5.5.2 Null Voltage. With the IMU gimbal angles commanded to 0.0° ±0.01° for the sine output and 90.0° ±0.01° for the cosine output, the total null voltage shall not exceed 100 mv rms and the inphase null shall not exceed 3.0 mv rms.

3.1.5.5.3 Phasing. The sine and cosine outputs shall be in phase (0°) with the reference for gimbal angles of +45.0° and shall be out of phase (180°) for gimbal angles of +225.0°.

3.1.5.6 IMU Cage. The IMU gimbals shall drive until the resolver 1X sine signals indicate 0±0.5V rms with the IMU gimbals initially coarse aligned to 10° and with the IMU Cage discrete present at the interface. [illegible]

3.1.6 RR/CDU Control Requirements

3.1.6 1 RR CDU Zero. This mode shall be initiated by entering Verb 40, Noun 55 at the LGC DSKY.

3.1.6.1.1 LGC Counters. The RR Shaft and Trunnion Counters at locations 00054 and 00053 in the LGC shall indicate all zeros.

3.1.6.2 RR Designate Mode. This mode shall be initiated by entering Verb 41, Noun 55 at the LGC DSKY.

3.1.6.2.1 RR CDU AC D/A Nulls. The RR CDU AC D/A outputs at the interface shall not exceed 0.30 volts rms subsequent to completion of the torquing command.

3.1.6.2.2 Angular Command Accuracy. The LGC shall command +9, +6, 0, -6, -9 degree increments to the shaft and trunnion CDU DAC's. The voltage output of the RR Shaft AC D/A Error and RR Trunnion AC D/A Error shall be +4.5±0.27, +3.00±0.18, less than 0.056, -3.0±0.18, and -4.5±0.27 volts rms respectively, the minus sign indicating that the output is out of phase with respect to the reference.

3.1.6.2.2.1 RR CDU Read Ambiguity. The RR shaft and trunnion CDU's shall be capable of repeating an angle of +225.0 (-135.0) to within 1 bit.

3.1.6.2.3 Angular Tracking Accuracy. With the RR Data good and the Auto Angle Track Enable discrete present and with a simulated Shaft and Trunnion gimbal angle of 45.00°, the Shaft and Trunnion counters in the LGC shall indicate the gimbal angles within ±0.02°.

Test/Examination	Requirement	JDC Method
PGNCS Caution	3.1.4.14	12617
Altitude Meters	3.1.4.15	12621
Rendezvous Radar	3.1.4.16	12621
IMU/CDU Control Requirements	3.1.5	N/A
CDU Zero	3.1.5.1	12617/12623
Coarse Align	3.1.5.2	12617/12623
Fine Align	3.1.5.3	12617/12619/12623
FDAI Linearity	3.1.5.4	12623
Total Attitude (GASTA) Interface	3.1.5.5	12623
IMU Cage	3.1.5.6	12616
RR/CDU Control Requirements	3.1.6	N/A
RR CDU Zero	3.1.6.1	12626
RR Designate Mode	3.1.6.2	12626
Velocity Meters	3.1.6.3	12623
Accelerometer Loops	3.1.7	N/A
PIPA Scale Factor	3.1.7.1	12624
PIPA Bias	3.1.7.2	12624
Stabilization Loops	3.1.8	N/A
Step Response	3.1.8.1	12619
Gimbal Torque Level	3.1.8.2	12619
IRIG Drift Coefficients	3.1.9	N/A
NBD	3.1.9.1	12624
ADIA	3.1.9.2	12624
ADSRA	3.1.9.3	12624
IRIG Scale Factor	3.1.10	12627
System Fine Alignment Accuracy	3.1.11	12625
Abort Guidance System	3.1.12	N/A
Gimbal Angle Transmission Accuracy	3.1.12.1	12619/12623
Prime Power	4.2.1.4.1	12618
Coolant Requirements	4.2.1.4.3	12611
Rotary Table Alignment Requirements	4.2.1.11	16010/16011/16012
Test Setup	4.2.1.12	sec par 4.2.1.12

4.2 GENERAL. The contractor responsible for system assembly shall be responsible for the accomplishment of each test required.

4.2.1 Test Conditions

4.2.1.1 Environmental. Unless otherwise specified, the system shall be tested under the following ambient conditions:

a. Temperature: 75° ±10°F
b. Relative Humidity: 90 percent max
c. Barometric Pressure: Ambient

g. Timing: (ref to A/2 point) leading edge:

(1) Start to bit sync: 19.5±5.0 μsec
(2) Bit sync to data: 1 μsec max
(3) Stop pulse: 19.5±5.0 μsec after last sync pulse
(4) There shall be 40-bit sync pulses between each start and stop pulse

4.2.1.4.2.5.2 Uplink Interface (UPLINK "0" and UPLINK "1"):

a. Source Impedance: 100 ohms -1; 10 ohms -0 max.
b. Amplitude (A): 7±3V
c. Pulse Width at A/2 Point: 3±1 μsec
d. Droop: 20 percent at 2 μsec
e. Maximum Backswing: 4V
f. Risetime: 0.2 μsec max. from 10 percent to 90 percent of A
g. Repetition Rate: 1K pps
h. Maximum Noise: No pulse - ±0.4V

4.2.1.4.2.6 ACE Bias 1 and 2. A switchable ground shall be supplied to each interface.

4.2.1.4.3 Coolant Requirements

4.2.1.4.3.1 IMU. The IMU shall be provided with water-glycol coolant at a temperature of 40° ±3°F and flow rate of 33±5 lb per hour.

4.2.1.4.3.2 PSA, CDU, PTA Headers. The PSA, CDU, and PTA cold plates shall be provided with coolant sufficient to maintain the header temperature below 70°F.

4.2.1.4.4 Inertial Component Temperature Sensor Current:

a. PIPA 6±0.12 ma dc
b. IRIG 2±0.04 ma dc

4.2.1.5 Test Data. All system test data shall be recorded on suitable reproducible forms and stored at the contractor's facility. Copies of the recorded data shall accompany the system. Where space is provided to indicate the value or specific reading obtained, the specific reading shall be recorded if a limit or limits is given for a test. Further, the initials of the individual performing the inspection shall be inserted above the value observed and recorded. If limits are not stated, it is required that the individual performing the test initial in the space provided indicating that the requirements were met.

4.2.1.6 Test Values. All test values given in Section 4 of this specification reflect allowances for instrumentation error, loads, or variation in supply voltages and frequencies.

4.2.1.7 Safety Precautions. Normal safety precautions required during testing of precision electromechanical equipment shall be followed.

4.2.1.8 Operational Precautions

4.2.1.8.1 G&N System Turn-On. The following conditions shall be met prior to IMU power application.

4.2.1.8.1.1 Initial Turn-On. If the IMU has just been installed in the test fixture, LGC power shall be applied with the IMU Standby power for a minimum of two hours.

4.2.1.8.1.2 General Turn-On. If the IMU Operate power has been applied to the G&N System through normal JDC procedures specified in Figure 2 and the IMU gimbals have been parked not in excess of five days or have not been moved since parking, LGC power shall be applied with the IMU Standby power for a minimum of three minutes. If the IMU gimbals have not been parked, an equivalent minute for minute waiting period with LGC and IMU Standby power applied shall be endured. If the waiting period is in excess of two hours, a two hour waiting period shall suffice.

4.2.1.8.2 G&N System Turn-Off. The following conditions shall be strictly adhered to prior to removal of G&N System power at the interface.

4.2.1.8.2.1 IMU Gimbal Parking. The IMU gimbals shall be positioned such that the PIPA and IRIG output axes are horizontal ±5°.

4.2.1.8.2.2 Power Turn-Off Sequence. Upon G&N System power removal, the IMU Operate power shall be turned off first. The IMU Standby and LGC power may then be turned off in that order.

4.2.1.8.3 Suspension Power. The LGC power (3200 cps suspension power) shall not be off while torquing the inertial components is taking place. Noncompliance shall result in degaussing and recalibration of the components.

4.2.1.8.4 Gimbal Lock. A Verb 36 shall be entered into the DSKY if the IMU Middle Gimbal is coarse aligned to within the gimbal lock limits greater than ±70°.

4.2.1.8.5 Inertial Component Performance Tests. The IMU Operate power must be applied for a minimum of one hour prior to performing JDC 12624.

4.2.1.9 Test Equipment Required. The test equipment utilized in whole or part as required by the respective JDC for the test being conducted shall be in accordance with Drawing 1900030.

4.2.1.10 Jigs and Fixtures. Test probes shall not be used to make direct electrical connections to connectors of the Apollo Guidance Equipment. Jigs made up of mating connectors shall be used.

4.2.1.11 Rotary Table Alignment Requirements. The Rotary Table Tilt axis shall be aligned parallel to true east within ±1 minute, and at 0° tilt the rotary axis shall be aligned within ±2 seconds of vertical.

4.2.1.11.1 Fixture Alignment and Calibration Procedures. The procedures shall be conducted in accordance with the following JDC's.

JDC 16010	Rotary Table Leveling Calibration Test
JDC 16011	IMU Mounting Fixture Alignment Test about the X and Y Axes
JDC 16012	IMU Mounting Fixture Alignment Test about the Z axis

The rotary axis and tilt axis calibrations shall be accomplished at 3 month intervals, in accordance with the following JDC's.

JDC 19728	Rotary Tilt and Rotary Axis Calibration

4.2.1.12 Test Setup. The APOLLO G&N equipment shall be tested and inspected under the test conditions specified herein.

4.2.1.12.1 Assembly Requirements. The G&N System shall be assembled to the G&N Ground Support Equipment and the assembly and test equipment interconnect procedures shall be conducted in accordance with the following JDC's:

JDC	DESCRIPTION
12600	LEM G&N System Visual Inspection
12601	LGC Installation
12602	Computer Control and Reticle Dimmer Assembly Installation
12603	"A" Harness Installation
12604	LGC Buffer Assembly Installation
12605	DSKY Installation
12606	"B" Harness Installation
12608	LEM G&N System Passive Test
12610	Coolant Hose Connection
12611	G&N Coolant Supply Turnon-TurnOff
16009	IMU & PTA Mounting Fixture Installation on the Rotary Table
16013	Installation of the IMU on the IMU Mounting Fixture
16014	Installation of the pulse torquing Assembly to the PTA Holding Fixture Assembly on the Rotary Table
16017	CDU Installation
16018	PSA Installation

4.2.1.13 Test Sequence. The sequence of operations shall be as specified in Figure 2.

4.2.2 Nonconforming Units. Failure of the system to pass any examination or test of this specification shall automatically classify the unit as nonconforming. Each nonconforming unit corrected shall be reinspected. Reinspection may be limited to the test or examination which defined the nonconformance, or, when directed by the cognizant inspector, a complete retest and reexamination may be required. Nonconforming units which have not been corrected will be considered for acceptance only upon formal application by the contractor to the cognizant NASA representative.

4.3 TESTS

4.3.1 Applicable JDC's. The JDC's specified in the index of 4.1 form the acceptance test procedures of this specification.

APOLLO G&N Specification
PS6015000 REV D
Original Issue Date:
Release Authority: TDRR 2534
Class A Release
CODE IDENT NO. 80230

MASTER END ITEM DETAIL SPECIFICATION

PART II

PRODUCT CONFIGURATION AND ACCEPTANCE TEST REQUIREMENTS

PGNCS SPACECRAFT EQUIPMENT

LEM

DRAWING NO. 6015000

MEI NO. 6015000

Record of Revisions

Date	Revision Letter	TDRR No.	Pages Revised	Approvals MIT	Approvals NASA
3/16/66	A	27208	4, 6-33 now 34 pages was 33.	WK	TM
3/15/66	B	27091	33	WK	TM
6/28/66	C	29846	4, 6, 7, 8, 11, 13, 15, 17, 18, 23,		
			30, 31, 32	MGM	ACM
9/28/66	D	31247	7, 17, 18, 19, 24	MGM EA	WLS

This specification consists of page 1 to 34 inclusive.

APPROVALS

NASA/MSC

MIT/IL

ACSP

3.1.2.2.3 Heater Telemetry Discrete. The Heater Telemetry Discrete shall cycle ON and OFF. The ON state shall be 26.5±7 vdc at the interface.

3.1.2.2.4 Blower Telemetry Discrete. The Blower Telemetry Discrete shall cycle ON and OFF. The ON state shall be 0±5V rms and the OFF state shall be 28.0±2.8V rms.

3.1.2.3 800 CPS Power Supply Temperature. The resistance of the temperature thermistor shall be 1.715K to 8.37K ohms.

3.1.2.4 Temperature Monitor 1. The resistance of the temperature thermistor shall be 1.4K to 13.25K ohms.

3.1.2.5 Calibration Module Temperature. The resistance of the temperature thermistor shall be 2.8K to 13.25K ohms.

3.1.2.6 +28 VDC IMU Operate. The IMU Operate voltage shall be 28.5+0, -1 vdc.

3.1.3 System Power Supplies. The system power supplies shall meet the following requirements.

3.1.3.1 IMU 28V, 1 Percent, 800 CPS Supply.

3.1.3.1.1 Voltage. The output voltage shall be 28.00±0.56V rms.

3.1.3.1.2 Frequency. The output frequency shall be 800±1 cps.

3.1.3.2 IMU 28V, 5 Percent, 800 CPS Supplies (Phases A and B)

3.1.3.2.1 Voltage. The output voltage of phase A shall be 28.0±1.4V rms and the output voltage of phase B shall be 28.0±1.1V rms.

3.1.3.2.2 Frequency. The frequency of the power supply outputs shall be 800±1 cps.

3.1.3.2.3 Phase. The output of the phase A supply shall be -90° ±10° with respect to the IMU 28V, 1 percent power supply output. The output of the phase B supply shall be -90° ±10° with respect to the IMU 28V, 5 percent, phase A power supply output.

c. Cos AMG 1X
d. Sin AMG 1X
e. Cos AOG 1X
f. Sin AOG 1X

3.1.5.5.1 Phase Shift. The phase of the cosine output shall be within 0.5° of the sin output. The phase of the sin output shall not exceed 6.0° ±5.0° with respect to the reference.

3.1.5.5.2 Null Voltage. With the IMU gimbal angles commanded to 0.0° ±0.01° for the sine output and 90.0° ±0.01° for the cosine output, the total null voltage shall not exceed 125 mv rms and the inphase null shall not exceed 75 mv rms.

3.1.5.5.3 Phasing. The sine and cosine outputs shall be in phase (0°) with the reference for gimbal angles of +45.0° and shall be out of phase (180°) for gimbal angles of +225.0°.

3.1.5.6 IMU Cage. The IMU gimbals shall drive until the resolver 1X sine signals indicate 0±0.5V rms with the IMU gimbals initially coarse aligned to 10° and with the IMU Cage discrete present at the interface. [illegible]

3.1.6 RR/CDU Control Requirements

3.1.6 1 RR CDU Zero. This mode shall be initiated by entering Verb 40, Noun 40 at the LGC DSKY.

3.1.6.1.1 LGC Counters. The RR Shaft and Trunnion Counters at locations 00036 and 00035 in the LGC shall indicate all zeros.

3.1.6.2 RR Designate Mode. This mode shall be initiated by entering Verb 41, Noun 40 at the LGC DSKY.

3.1.6.2.1 RR CDU AC D/A Nulls. The RR CDU AC D/A outputs at the interface shall not exceed 0.30 volts rms subsequent to completion of the torquing command.

3.1.6.2.2 Angular Command Accuracy. The LGC shall command +9, +6, 0, -6, -9 degree increments to the shaft and trunnion CDU DAC's. The voltage output of the RR Shaft AC D/A Error and RR Trunnion AC D/A Error shall be +4.5±0.27, +3.00±0.18, less than 0.056, -3.0±0.18, and -4.5±0.27 volts rms respectively, the minus sign indicating that the output is out of phase with respect to the reference.

3.1.6.2.2.1 RR CDU Read Ambiguity. The RR shaft and trunnion CDU's shall be capable of repeating an angle of +240.0 (-120.0) to within 1 bit.

3.1.6.2.3 Angular Tracking Accuracy. With the RR Data good and the Auto Angle Track Enable discrete present and with a simulated Shaft and Trunnion gimbal angle of 240.00°, the Shaft and Trunnion counters in the LGC shall indicate the gimbal angles within ±0.02°.

3.1.6.2.3.1 Shaft and Trunnion 1X Resolver Interface. The Shaft and Trunnion 1X sine and cosine outputs shall be -24.2±1.2 volts rms and -14.0±0.7 volts rms respectively at a 1X angle of 240.2°. [illegible] 18.65±.95 volts rms at a 1X angle of 45.000°.

3.1.6.2.3.2 Shaft and Trunnion 16X Resolver Interface. The Shaft and Trunnion 16X sine and cosine outputs shall be 3.535±0.215 volts rms at a 1X angle of 2.812°.

3.1.6.2.3.3 RR CDU Fine Error. The steady state voltage of the RR Shaft Fine Error and RR Trunnion Fine Error outputs shall not exceed 0.070 volts rms.

3.1.6.2.3.4 RR CDU Coarse Error. The steady state voltage of the RR Shaft Coarse Error and RR Trunnion Coarse Error outputs shall not exceed 0.680 volts rms.

3.1.6.2.3.5 RR CDU Fail. CDU Fail indicated by a "0" in bit 7 of Channel 30 shall occur with a difference of 1.0° ±0.1° (fine error) or 33.75° ±0.3° (coarse error) between the CDU read counter and the RR gimbal resolvers.

3.1.6.2.3.6 RR Auto-Angle Track Enable Command. A "1" in bit 14 of Channel 12 shall result in a voltage of less than 5 vdc. A "0" in bit 14 of Channel 12 shall result in a voltage of 10±1 vdc.

3.1.6.3 Velocity Meters. When the Display Inertial Data discrete is present, the Lateral and Forward velocity outputs shall be as specified when the following rates are commanded by the LGC.

LGC Bits	CDU DC DAC Output (vdc)
0	±0.007*
1	+0.013 ±10%
2	+0.026 ±10%
4	+0.053 ±10%
8	+0.105 ±6%
16	+0.211 ±6%
32	+0.422 ±6%
64	+0.844 ±6%
128	+1.687 ±6%
160	+2.109 ±6%
256	+3.374 ±6%
359	+4.732 ±6%
358	+4.718 ±6%
-160	-2.109 ±6%
-359	-4.732 ±6%

* Noise: At DC Null; less than 5.0 mv rms at frequencies below 25 cps, 30 mv rms at frequencies above 25 cps.

3.1.7 Accelerometer Loops

3.1.7.1 PIPA Scale Factor. The PIPA scale factor in a 1g field shall be 1.000 cm/sec/pulse ±400 ppm, cm/sec/pulse.

APOLLO G&N Specification
PS6015000 REV E
Original Issue Date:
Release Authority: TDRR 2534
Class A Release
CODE IDENT NO. 80230

MASTER END ITEM DETAIL SPECIFICATION

PART II

PRODUCT CONFIGURATION AND ACCEPTANCE TEST REQUIREMENTS

PGNCS SPACECRAFT EQUIPMENT

LEM

DRAWING NO. 6015000

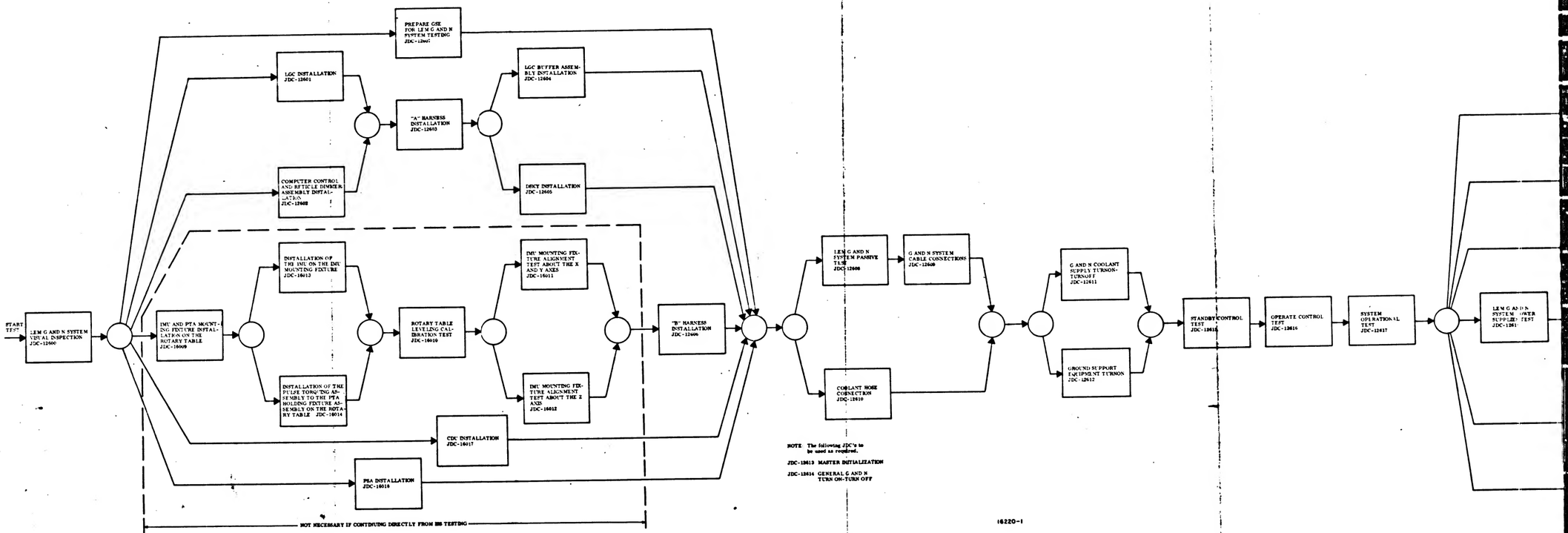
MEI NO. 6015000

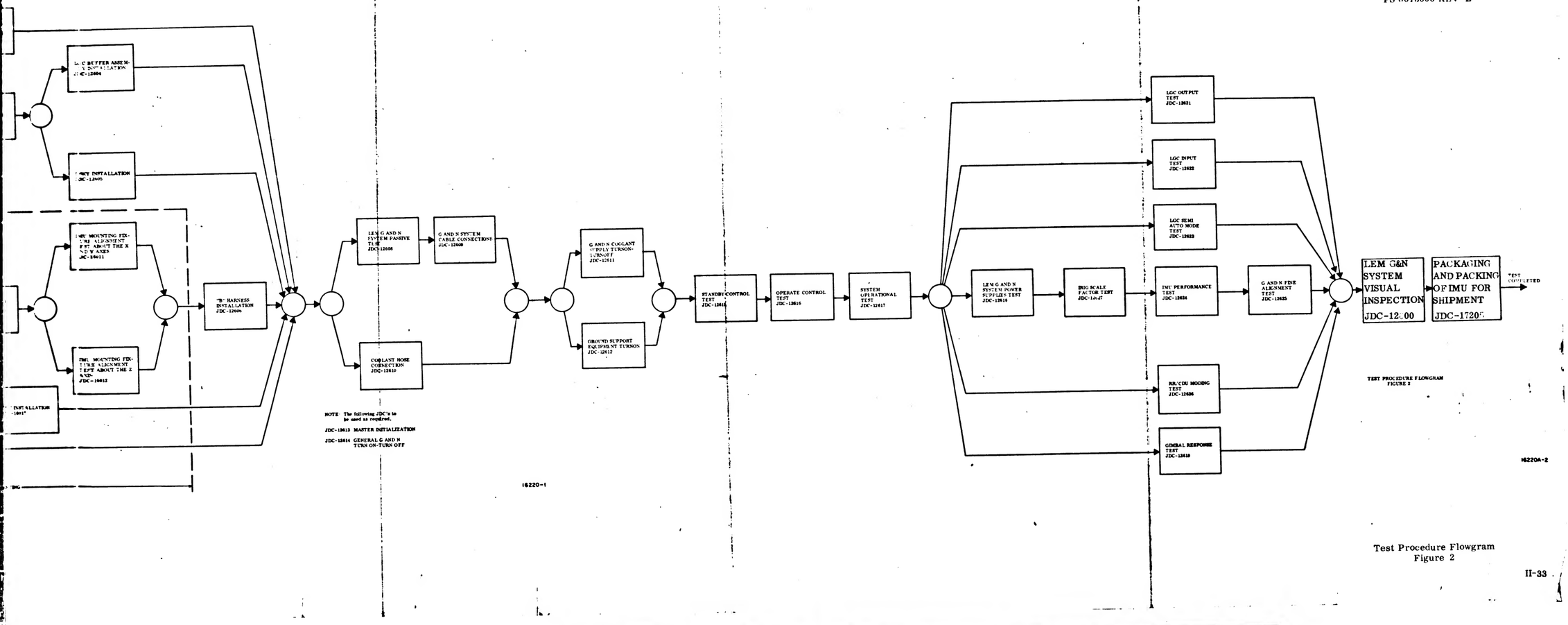
Record of Revisions

Date	Revision Letter	TDRR No.	Pages Revised	Approvals MIT	Approvals NASA
3/16/66	A	27208	4, 6-33 now 34 pages was 33	WK	TM
3/15/66	B	27091	33	WK	TM
6/28/66	C	29846	4, 6, 7, 8, 11, 13, 15, 17, 18, 23, 30, 31, 32	MGM	ACM
9/28/66	D	31247	7, 17, 18, 19, 24	MGM EA	WLS
11/1/66	E	31734	33, 34	MGM EA	WLS

This specification consists of page 1 to 34 inclusive.

APPROVALS	NASA/MSC	MIT/IL	ACSP


PREPARE GSE FOR LEM G AND N SYSTEM TESTING JDC-12607
LGC INSTALLATION JDC-12601
"A" HARNESS INSTALLATION JDC-12603
LGC BUFFER ASSEMBLY INSTALLATION JDC-12604
COMPUTER CONTROL AND RETICLE DIMMER ASSEMBLY INSTALLATION JDC-12602
DSKY INSTALLATION JDC-12605
START TEST
LEM G AND N SYSTEM VISUAL INSPECTION JDC-12600
IMU AND PTA MOUNTING FIXTURE INSTALLATION ON THE ROTARY TABLE JDC-16009
INSTALLATION OF THE IMU ON THE IMU MOUNTING FIXTURE JDC-16013
INSTALLATION OF THE PULSE TORQUING ASSEMBLY TO THE PTA HOLDING FIXTURE ASSEMBLY ON THE ROTARY TABLE JDC-16014
ROTARY TABLE LEVELING CALIBRATION TEST JDC-16010
IMU MOUNTING FIXTURE ALIGNMENT TEST ABOUT THE X AND Y AXES JDC-16011
IMU MOUNTING FIXTURE ALIGNMENT TEST ABOUT THE Z AXIS JDC-16012
"B" HARNESS INSTALLATION JDC-12606
CDU INSTALLATION JDC-16017
PSA INSTALLATION JDC-16018
NOT NECESSARY IF CONTINUING DIRECTLY FROM HS TESTING
LEM G AND N SYSTEM PASSIVE TEST JDC-12608
G AND N SYSTEM CABLE CONNECTIONS JDC-12609
COOLANT HOSE CONNECTION JDC-12610
G AND N COOLANT SUPPLY TURNON-TURNOFF JDC-12611
GROUND SUPPORT EQUIPMENT TURNON JDC-12612
STANDBY CONTROL TEST JDC-12615
OPERATE CONTROL TEST JDC-12616
SYSTEM OPERATIONAL TEST JDC-12617
LEM G AND N SYSTEM POWER SUPPLIES TEST JDC-12611
NOTE The following JDC's to be used as required.
JDC-12613 MASTER INITIALIZATION
JDC-12614 GENERAL G AND N TURN ON-TURN OFF
16220-1



Test Procedure Flowgram
Figure 2

5. PREPARATION FOR DELIVERY

5.1 GENERAL. With the exception of the IMU, preparation for delivery shall be in accordance with Specification ND1002214.

5.2 IMU Preparation for Shipment. The Inertial Measurement Unit shall be prepared for shipment in accordance with JDC17205, Packaging and Packing of IMU for Shipment.

6. NOTES. (To be supplied)

6.1 DEFINITIONS AND ABBREVIATIONS

APOLLO G&N Specification
PS6015000 REV E
Original Issue Date:
Release Authority: TDRR 2534
Class A Release
CODE IDENT NO. 80230

MASTER END ITEM DETAIL SPECIFICATION

PART II

PRODUCT CONFIGURATION AND ACCEPTANCE TEST REQUIREMENTS

PGNCS SPACECRAFT EQUIPMENT

LEM

DRAWING NO. 6015000

MEI NO. 6015000

Record of Revisions

Date	Revision Letter	TDRR No.	Pages Revised	Approvals MIT	Approvals NASA
3/16/66	A	27208	4, 6-33 now 34 pages was 33.	WK	TM
3/15/66	B	27091	33	WK	TM
6/28/66	C	29846	4, 6, 7, 8, 11, 13, 15, 17, 18, 23,		
			30, 31, 32	MGM	ACM
9/28/66	D	31247	7, 17, 18, 19, 24	MGM EA	WLS
11/1/66	E	31734	33, 34	MGM EA	WLS
12/29/66	F	32463	4, 6-10, 14, 15, 18, 20	MGM JP	RJJ

This specification consists of page 1 to 34 inclusive.

APPROVALS	NASA/MSC	MIT/IL	ACSP
		15 Jan 1966	

3. REQUIREMENTS

3.1 PERFORMANCE

3.1.1 Standby Control

3.1.1.1 LEM Standby Mode. The following requirements shall be met with the IMU in the standby condition.

3.1.1.1.1 28 VDC IMU Standby. The IMU Standby voltage shall be 22.0±1.0 vdc.

3.1.1.1.2 Inertial Component Temperature. The mean stabilized PIPA temperature shall be 130.5±1.5°F within 1 hour after entering the Standby Mode. The mean stabilized IRIG temperature shall be within 3.0°F of the PIPA temperature.

3.1.1.2 G&N Standby Mode (LGC STBY). The following requirements shall be met with the IMU in the standby condition and the LGC in the standby condition.

3.1.1.2.1 28 VDC IMU Standby. The IMU Standby voltage shall be 28.0±1.0 vdc.

3.1.1.2.2 3200 cps Suspension Power. The 3200 cps suspension voltage shall be 28.6±0.56 volts rms at a frequency of 3200±1 cps.

3.1.1.2.3 Master Clock Sync. The Master Clock Sync signal characteristics shall be as follows. (See Figure 1).

a. Amplitude: 4.0 volts minimum.
b. Pulse Width: 0.50±0.25 microseconds.
c. Rise Time: 0.2 microseconds max. from 10 to 90 percent of amplitude.
d. Frequency: 1024K pps ±2 ppm over a 15 minute period.

3.1.1.3 G&N Standby Mode(LGC Operate). The following requirements shall be met with the IMU in the standby condition, the LGC in the operate condition, and the LGC +4 and +14 volt dc power supplies at 4.0±0.15 and 14.0±0.2, respectively.

3.1.1.3.1 LGC Voltage Fail Alarm Limits. A Voltage Fail alarm shall occur as indicated by the presence of a LGC Warning discrete, at a voltage within each of the following power supply output limits: the following outputs:

	Power Supply	Low Alarm Limits (vdc)	High Alarm Limits (vdc)
a.	+4 vdc ±0.5 vdc	+3.85±0.15 vdc	4.40±0.20
b.	+14 vdc ±0.5 vdc	+12.5±0.30 vdc	16.0±0.40
c.	+4, ±0.2 vdc	+14, ±0.2 vdc	

The LGC ALARM CONDITION lamp shall not illuminate when the +4 vdc power supply is 3.90 vdc to 4.10 vdc or when the +14 vdc power supply is 12.9 vdc to 15.5 vdc.

3.1.1.3.2 Inhibit Power Fail. The LGC shall exhibit no failures with the Inhibit Power Fail discrete present.

3.1.1.3.3 Voltage Margin Requirements. No LGC failure indication shall occur under the following conditions with the Inhibit Power Fail discrete present:

a. The +4 vdc supply shall be varied from a maximum low of 3.4 vdc to a maximum high of 4.5 vdc with the +14 vdc supply held at 12.1 vdc nominally and at 16.4 vdc nominally.

b. The +14 vdc supply shall be varied from a maximum low of 12.1 vdc to a maximum high of 16.4 vdc with the +4 vdc supply held at 3.40 vdc nominally and at 4.6 vdc nominally.

3.1.1.4 Reticle Lamp Voltage. The variable AOT Reticle Lamp Voltage shall have the following characteristics at the interface:

a. Minimum Voltage: less than −0.27 vdc
b. Maximum Voltage: −4.67 vdc

3.1.2 Operate Control

3.1.2.1 IMU Operate Delay Indication. LGC Channel 30 shall indicate a "0" in bit 14 when the system is supplied with the +28.0±0.5 VDC IMU Operate power and shall remain in the "0" state for 90±5 seconds, after which time bit 14 of Channel 30 and bit 15 of Channel 12 shall indicate a "1".

3.1.2.1.1 Inertial Component Pulse Torquing. During the 90 second delay period, the IRIG and PIPA pulse torque power supply shall be inhibited. Loss of +28 VDC LGC prime power shall result in the same condition.

3.1.2.1.2 Automatic Caging and CDU Ambiguity Operation. The IMU gimbal resolvers shall drive until the 1X sine signals indicate 0.00±0.50 volts rms and the 1X cosine signals indicate 26.0±2.6 volts rms, with the IMU gimbal angles initially at 225°.

3.1.2.2 Inertial Component Temperature. The following requirements shall be met in the Operate mode with IMU gimbals coarse aligned to 0° ±5°.

3.1.2.2.1 Standby to Operate Transient. The mean stabilized PIPA temperature in the Operate mode shall be within 0.50°F of the mean stabilized PIPA temperature in the Standby mode.

3.1.2.2.1.1 Standby to Operate Transient Time. The PIPA temperature 15 minutes after switching from the Standby to Operate mode shall be within 0.5°F of the mean stabilized Operate mode PIPA temperature. The IRIG temperature 30 minutes after switching from the Standby to Operate mode shall be within 0.5°F of the mean stabilized Operate mode IRIG temperature.

3.1.2.2.2 Inertial Component Temperature Control Point. The mean stabilized temperature of the PIPA and IRIG components shall be within 130.5±1.5°F and 135±2.5°F, respectively. The PIPA and IRIG temperature are stabilized when they have not changed by more than 0.1°F over a one hour period.

3.1.3.10 LGC +28 VDC. The +28 vdc COMP TP voltage shall be +28.0 +5.5, -3.5 vdc.

3.1.4 LEM Guidance Computer (LGC)

3.1.4.1 Operational Self-Check. The LGC program shall sum fixed memory; verify the execution of the machine instructions, control pulses, interupts, and timing; and exercise the erasable, central, and special registers. In addition, the program shall verify the proper operation of all electro-luminescent displays on the DSKY.

3.1.4.2 Keyboard Operation. Actuation of each listed pushbutton shall result in a displayed indication as follows:

a. Verb: (preceding and in conjunction with two numeral pushbuttons) shall result in the illumination of the same numerals in the VERB display window.

b. Noun: (preceding and in conjunction with two numeral pushbuttons) shall result in the illumination of the same numerals in the NOUN display window.

c. 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, +, - : shall result in illumination of the respective characters on the DSKY display.

d. CLR: shall result in deletion of illuminated characters on R-1, R-2, and R-3 during a data load sequence on the DSKY display, provided the ENTER pushbutton has not been pressed during the entry sequence.

e. STBY: shall extinguish all DSKY illumination except that of the STBY RESTART and TEMP lamps after preparing the LGC for STBY.

f. RSET: shall extinguish any or all of the following DSKY display lamps when so illuminated.

(1) PROG
(2) RESTART
(3) OPR ERR

g. KEY REL: shall extinguish the KEY REL DSKY display lamp and return the DSKY control to the monitoring routine which is commanded by the LGC.

h. ENTER: shall result in the completion of a legal entry depending upon the actuation of the proper sequence of VERB, or VERB, NOUN, plus numeral pushbuttons.

3.1.4.3 Display Operation. Each listed display lamp shall illuminate as a result of specified stimuli.

a. All listed lamps (b through m) shall be capable of lamp element operation verification through the use of VERB 35.

b. STBY: shall illuminate after actuation of the STBY pushbutton for at least 2 seconds after preparing the LGC for STBY.

c. KEY REL: shall illuminate by presence of a "1" in bit 5 of CH 11

d. GIMBAL LOCK: shall illuminate by presence of a "1" in bit 6 of RLYWD 1100 as a result of the MIDDLE gimbal CDU indicating angles between +07000 and +28000 as demonstrated by interrogation of the CDU counter address (Q0034) in the LGC.

e. TEMP: shall illuminate by presence of a "1" in bit 4 of CH 11.

f. PROG: shall illuminate by presence of a "1" in bit 9 of RLYWD 1100 subsequent to an illegal program function or PIPA FAIL.

g. RESTART: shall only illuminate as a result of any or all of the following conditions:

(1) STANDBY
(2) TC TRAP
(3) RUPT LOCK
(4) PARITY FAIL
(5) NIGHT WATCHMAN
(6) VOLTAGE FAIL

h. TRACKER: shall illuminate by presence of a "1" in bit 8 of RLYWD 1100.

i. OPR ERR: (Flashing) shall illuminate by presence of a "1" in bit 7 of CH 11.

j. COMP ACTY: shall illuminate by presence of a "1" in bit 2 of CH 11.

k. UPLINK ACTY: shall illuminate by presence of a "1" in bit 3 of CH 11.

m. Electro-luminescent Elements: The following numeric displays shall illuminate by program or DSKY stimuli or both.

(1) PROG
(2) VERB } Flashing when program stimulation causes the presence
(3) NOUN } of a "1" in bit 6 of Channel 11.
(4) REGISTER 1
(5) REGISTER 2
(6) REGISTER 3

3.1.4.4 LGC Commands to Reaction Control System (RCS). With a "1" in the following bit assignments, a voltage of 8 to 6 vdc shall be present at the interface. With a "0" in the following bit assignments, a voltage of 10±0.5 vdc shall be present at the interface.

Channel 5	Bit No.	Channel 5	Bit No.
+X RCS Jet 4D	2	-X RCS Jet 4U	1
+X RCS Jet 3D	4	-X RCS Jet 3U	3
+X RCS Jet 2D	6	-X RCS Jet 2U	5
+X RCS Jet 1D	8	-X RCS Jet 1U	7

3.1.7.2 PIPA Bias. The PIPA bias in a 1g field shall not exceed 0.5 cm/sec^2.

3.1.8 Stabilization Loops

3.1.8.1 Step Response. The IRIG floats shall be initially displaced from electrical null by application of 10, 5 and 5 vdc ±5 percent to the test inputs of the respective Inner, Middle and Outer gimbal DC Amplifiers and shall return to null upon removal of this voltage. The time interval between the removal of this disturbance and the settling to within 5 percent of steady-state value shall not exceed 0.1 second. In addition, the number of oscillations outside the 5 percent tolerance band shall not exceed 3.

3.1.8.2 Gimbal Torque Level. The friction level of each gimbal, when torqued by its IRIG shall not exceed 26.2 in-oz, indicated by a peak torque motor current not exceeding 0.125 amps.

3.1.9 IRIG Drift Coefficients

3.1.9.1 NBD. The IRIG bias drift (NBD) shall not deviate more than 5.0 meru from the associated REFERENCE VALUE as established from the performance of ATP6015497.

3.1.9.2 ADIA. The IRIG drift due to acceleration along the input axis (ADIA) shall not deviate more than 15 meru/g from the associated REFERENCE VALUE as established from the performance of ATP6015497.

3.1.9.3 ADSRA. The IRIG drift due to acceleration along the spin reference axis (ADSRA) shall not deviate more than 10 meru/g from the associated REFERENCE VALUE as established from the performance of ATP6015497.

3.1.10 IRIG Scale Factor. The IRIG pulse torque scale factor shall be 2π radians/2^{21} pulses ±1750 ppm.

3.1.11 System Fine Alignment Accuracy. The stable member (SM) as defined by the X, Y, and Z PIPA input axes shall be aligned to predetermined orientations with respect to the IMU mounting pads with a maximum error of 105 arc seconds about any PIPA input axis as accomplished by an LGC alignment.

3.1.12 Abort Guidance System

3.1.12.1 Gimbal Angle Transmission Accuracy. A plus and minus gimbal angle increment (ΔA) about each axis shall be commanded by the LGC. A total pulse count of ΔA (0.01098) ±1 pulse shall be present on the plus and minus $\Delta\theta$ abort signals.

3.1.12.1.1 Pulse Characteristics of $\Delta\theta$ Abort Signals. With a constant rate of change of the $\Delta\theta$ Abort pulse commanded by the LGC, the pulse characteristics of the $\Delta\theta$ Abort signals shall be as follows. (See Figure 1).

a. Amplitude (A): 7±3 volts peak
b. Risetime: 0.5 microseconds at 10% to 90% of A
c. Pulse Width: 3.0±1.0 microseconds at 50% of A
d. Droop: 20% of A max
e. No Pulse Amplitude: -4.0 volts min to +4 volts max with reference to the zero vdc reference.

APOLLO G&N Specification
PS6015000 REV G
Original Issue Date:
Release Authority: TDRR 2534
Class A Release
CODE IDENT NO. 80230

MASTER END ITEM DETAIL SPECIFICATION

PART II

PRODUCT CONFIGURATION AND ACCEPTANCE TEST REQUIREMENTS

PGNCS SPACECRAFT EQUIPMENT

LEM

DRAWING NO. 6015000

MEI NO. 6015000

Record of Revisions

Date	Revision Letter	TDRR No.	Pages Revised	Approvals AC	Approvals NASA
3/16/66	A	27208	4, 6-33 now 34 pages was 33.	WK	TM
3/15/66	B	27091	33	WK	TM
6/28/66	C	29846	4, 6, 7, 8, 11, 13, 15, 17, 18, 23,		
			30, 31, 32	MGM	ACM
9/28/66	D	31247	7, 17, 18, 19, 24	MGM EA	WLS
11/1/66	E	31734	33, 34	MGM EA	WLS
12/29/66	F	32463	4, 6-10, 14, 15, 18, 20	MGM JP	RJJ
3/23/67	G	33218	6, 7, 19-35. Specification was	MGM EA	WLS
			34 pages, now 35 pages.		

This specification consists of page 1 to 35 inclusive.

APPROVALS	NASA/MSC	MIT/IL	AC	

3.1.1.3.2 Inhibit Power Fail. The LGC shall exhibit no failures with the Inhibit Power Fail discrete present.

3.1.1.3.3 Voltage Margin Requirements. No LGC failure indication shall occur under the following conditions with the Inhibit Power Fail discrete present.

a. The +4 vdc supply shall be varied from a maximum low of 3.4 vdc to a maximum high of 4.5 vdc with the +14 vdc supply held at 12.1 vdc nominally and at 16.4 vdc nominally.

b. The +14 vdc supply shall be varied from a maximum low of 12.1 vdc to a maximum high of 16.4 vdc with the +4 vdc supply held at 3.40 vdc nominally and at 4.6 vdc nominally.

3.1.1.4 Reticle Lamp Voltage. The variable AOT Reticle Lamp Voltage shall have the following characteristics at the interface:

a. Minimum Voltage: less than -0.27 vdc
b. Maximum Voltage: -4.67 vdc

3.1.2 Operate Control

3.1.2.1 IMU Operate Delay Indication. LGC Channel 30 shall indicate a "0" in bit 14 when the system is supplied with the +28.0±0.5 VDC IMU Operate power and shall remain in the "0" state for 90±5 seconds after which time bit 14 of Channel 30 and bit 15 of Channel 12 shall indicate a "1".

3.1.2.1.1 Inertial Component Pulse Torquing. During the 90 second delay period, the IRIG and PIPA pulse torque power supply shall be inhibited. Loss of +28 VDC LGC prime power shall result in the same condition.

3.1.2.1.2 Automatic Caging and CDU Ambiguity Operation. The IMU gimbal resolvers shall drive until the 1X sine signals indicate 0.00±0.50 volts rms and the 1X cosine signals indicate 26.0±2.6 volts rms, with the IMU gimbal angles initially at 225°.

3.1.2.2 Inertial Component Temperature. The following requirements shall be met in the Operate mode with IMU gimbals coarse aligned to 0° ±5°.

3.1.2.2.1 Standby to Operate Transient. The PIPA temperature, during the first 15 minutes after switching from the Standby mode to the Operate mode, shall be within 0.5°F of the temperature specified in 3.1.1.1.2. At 15 minutes the PIPA temperature shall be within 0.5°F of its stabilized value. At 30 minutes the IRIG temperature shall be within 0.5°F of its stabilized value.

3.1.2.2.2 Inertial Component Temperature Control Point. The stabilized values of the PIPA and IRIG temperatures shall be 130.5±1.5°F and 135±2.5°F, respectively. The stabilized PIPA temperature shall be within 1.0°F of the stabilized PIPA temperature measured in 3.1.1.1.2. The temperature shall be considered stabilized when the temperature change is less than 0.1°F for 30 minutes.

3.1.2.2.3 Heater Telemetry Discrete. The Heater Telemetry Discrete shall cycle ON and OFF. The ON state shall be 26.5±7 vdc at the interface.

3.1.2.2.4 Blower Telemetry Discrete. The Blower Telemetry Discrete shall cycle ON and OFF with a heater duty cycle of approximately 45 percent. The ON state shall be 0±5V rms and the OFF state shall be 28.0±2.8V rms.

NOTE: With the operating parameters given in this specification, the blowers will always be on.

3.1.2.3 800 CPS Power Supply Temperature. The resistance of the temperature thermistor shall be 2.21K to 8.37K ohms.

3.1.2.4 Temperature Monitor 1. The resistance of the temperature thermistor shall be 1.4K to 13.25K ohms.

3.1.2.5 Calibration Module Temperature. The resistance of the temperature thermistor shall be 2.65K to 13.25K ohms.

3.1.2.6 +28 VDC IMU Operate. The IMU Operate voltage shall be 28.5+0, -1 vdc.

3.1.3 System Power Supplies. The system power supplies shall meet the following requirements.

3.1.3.1 IMU 28V, 1 Percent, 800 CPS Supply

3.1.3.1.1 Voltage. The output voltage shall be 28.00±0.56V rms.

3.1.3.1.2 Frequency. The output frequency shall be 800±1 cps.

3.1.3.2 IMU 28V, 5 Percent, 800 CPS Supplies (Phases A and B)

3.1.3.2.1 Voltage. The output voltage of phase A shall be 28.0±1.4V rms and the output voltage of phase B shall be 28.0±2.1V rms.

3.1.3.2.2 Frequency. The frequency of the power supply outputs shall be 800±1 cps.

3.1.3.2.3 Phase. The output of the phase A supply shall be -90° ±10° with respect to the IMU 28V, 1 percent power supply output. The output of the phase B supply shall be -90° ±10° with respect to the IMU 28V, 5 percent, phase A power supply output.

3.1.7.2 PIPA Bias. The PIPA bias in a 1g field shall not exceed 3.10 cm/sec^2 maximum limit and shall conform to the stability requirements of 3.1.14.

3.1.8 Stabilization Loops

3.1.8.1 Step Response. The IRIG floats shall be initially displaced from electrical null by application of 10, 5 and 5 vdc ±5 percent to the test inputs of the respective Inner, Middle and Outer gimbal DC Amplifiers and shall return to null upon removal of this voltage. The time interval between the removal of this disturbance and the settling to within 5 percent of steady state values shall not exceed 0.1 second. In addition, the number of oscillations outside the 5 percent tolerance band shall not exceed 3.

3.1.8.2 Gimbal Torque Level. The friction level of each gimbal, when torqued by its IRIG shall not exceed 26.2 in-oz, indicated by a peak torque motor current not exceeding 0.125 amps.

3.1.9 IRIG Drift Coefficients

3.1.9.1 NBD. The IRIG bias drift (NBD) shall not exceed 15.0 meru maximum limit and shall conform to the stability requirements of paragraph 3.1.14.

3.1.9.2 ADIA. The IRIG drift due to acceleration along the input axis (ADIA) shall not exceed 100 meru/g maximum limit and shall conform to the stability requirements of 3.1.14.

3.1.9.3 ADSRA. The IRIG drift due to acceleration along the spin reference axis (ADSRA) shall not exceed 40 meru/g maximum limit and shall conform to the stability requirements of 3.1.14.

3.1.10 IRIG Scale Factor. The IRIG pulse torque scale factor shall be 2π radians/2^{21} pulses ±1750 ppm.

3.1.11 System Fine Alignment Accuracy. The stable member (SM) as defined by the X, Y and Z PIPA input axes shall be aligned to predetermined orientations with respect to the AOT LOS with a maximum error of 600 arc seconds about any PIPA input axis as accomplished by an LGC alignment. The maximum error shall not include the PIPA bias terms.

NOTE: This is a Post S/C Installation Test Requirement only.)

3.1.12 Abort Guidance System

3.1.12.1 Gimbal Angle Transmission Accuracy. A plus and minus gimbal angle increment (ΔA) about each axis shall be commanded by the LGC. A total pulse count of ΔA (0.01098) ±1 pulse shall be present on the plus and minus $\Delta\theta$ abort signals.

3.1.12.1.1 Pulse Characteristics of $\Delta\theta$ Abort Signals. With a constant rate of change of the $\Delta\theta$ Abort pulse commanded by the LGC, the pulse characteristics of the $\Delta\theta$ Abort signals shall be as follows. (See Figure 1).

a. Amplitude (A): 7±3 volts peak
b. Risetime: 0.5 microseconds at 10% to 90% of A
c. Pulse Width: 3.0±1.0 microseconds at 50% of A
d. Droop: 20% of A max
e. No Pulse Amplitude: -4.0 volts min to +4 volts max with reference to the zero vdc reference.

3.1.14.3 Stability Requirements. Failure to be within the maximum values given for D_1, D_2, or D_3 in 3.1.14.1 after the retest sequence of 3.1.14.2 has been completed shall constitute failure of the assembly.

3.1.14.4 PIPA Degaussing. If a PIPA is degaussed, it shall be retested in the sequence as indicated in 3.1.14.2. The requirements of 3.1.14.2 shall then apply. Data taken prior to the degaussing shall not be used in calculating stability terms.

3.2 PRODUCT CONFIGURATION

3.2.1 Drawings. The configuration of the assembly shall be in accordance with APOLLO G&N Drawing 6015000 and all drawings and engineering data referenced thereon.

3.2.2 Maximum Weight

4. QUALITY ASSURANCE PROVISIONS

4.1 PRODUCT PERFORMANCE AND CONFIGURATION REQUIREMENTS/QUALITY VERIFICATION CROSS REFERENCE INDEX

Test/Examination	Requirement	JDC Number
Standby Control	3.1.1	12615
LEM Standby Mode	3.1.1.1	12615
G&N Standby Mode (LGC STBY)	3.1.1.2	12615
G&N Standby Mode (LGC Operate)	3.1.1.3	12615
Operate Control	3.1.2	N/A
IMU Operate Delay Indication	3.1.2.1	12616
Inertial Component Temperature	3.1.2.2	12616
800 CPS Power Supply Temperature	3.1.2.3	12616
Temperature Monitor 1	3.1.2.4	12616
Calibration Module Temperature	3.1.2.5	12616
+28 VDC Operate	3.1.2.6	12616
System Power Supplies	3.1.3	12618
IMU 28V, 1%, 800 CPS Supply	3.1.3.1	12618
IMU 28V, 5%, 800 CPS Supplies (Phase A and B)	3.1.3.2	12618
ECDU +4 VDC Supply	3.1.3.3	12618
Minus 28 VDC Supply	3.1.3.4	12618
Pulse Torque Power Supply	3.1.3.5	12618
800 CPS Reference Voltage	3.1.3.6	12618
3200 CPS Suspension Power	3.1.3.7	12618
LGC +4 VDC Power Supply	3.1.3.8	12618
LGC +14 VDC Power Supply	3.1.3.9	12618
LGC +28 VDC	3.1.3.10	12618
LEM Guidance Computer	3.1.4	N/A
Operational Self-Check	3.1.4.1	12617
Keyboard Operation	3.1.4.2	12617
Display Operation	3.1.4.3	12617
LGC Commands to RCS	3.1.4.4	12621
LGC Commands to Main Engine	3.1.4.5	12621
LGC Commands to SCS	3.1.4.6	12621
LGC Discrete Inputs	3.1.4.7	12622
Landing Radar Requirements	3.1.4.8	12621
Attitude Hand Controller	3.1.4.9	12622
Telemetry Uplink	3.1.4.10	12622
Telemetry Downlink	3.1.4.11	12621
LGC Warning	3.1.4.12	12617
ISS Warning	3.1.4.13	12617

Test/Examination	Requirement	JDC Method
PGNCS Caution	3.1.4.14	12617
Altitude Meters	3.1.4.15	12621
Rendezvous Radar	3.1.4.16	12621
IMU/CDU Control Requirements	3.1.5	N/A
CDU Zero	3.1.5.1	12617/12623
Coarse Align	3.1.5.2	12617/12623
Fine Align	3.1.5.3	12617/12619/12623
FDAI Linearity	3.1.5.4	12623
Total Attitude (GASTA) Interface	3.1.5.5	12623
IMU Cage	3.1.5.6	12616
RR/CDU Control Requirements	3.1.6	N/A
RR CDU Zero	3.1.6.1	12626
RR Designate Mode	3.1.6.2	12626
Velocity Meters	3.1.6.3	12623
Accelerometer Loops	3.1.7	N/A
PIPA Scale Factor	3.1.7.1	12624
PIPA Bias	3.1.7.2	12624
Stabilization Loops	3.1.8	N/A
Step Response	3.1.8.1	12619
Gimbal Torque Level	3.1.8.2	12619
IRIG Drift Coefficients	3.1.9	N/A
NBD	3.1.9.1	12624
ADIA	3.1.9.2	12624
ADSRA	3.1.9.3	12624
IRIG Scale Factor	3.1.10	12627
~~System Fine Alignment Accuracy~~	~~3.1.11~~	~~12625~~
Abort Guidance System	3.1.12	N/A
Gimbal Angle Transmission Accuracy	3.1.12.1	12619/12623
Prime Power	4.2.1.4.1	12618
Coolant Requirements	4.2.1.4.3	12611
Rotary Table Alignment Requirements	4.2.1.11	16010/16011/16012
Test Setup	4.2.1.12	sec par 4.2.1.12

4.2 GENERAL. The contractor responsible for system assembly shall be responsible for the accomplishment of each test required.

4.2.1 Test Conditions

4.2.1.1 Environmental. Unless otherwise specified, the system shall be tested under the following ambient conditions:

a. Temperature: 75° ±10°F
b. Relative Humidity: 90 percent max
c. Barometric Pressure: Ambient

4.2.1.2 Prior Compliance. Prior to system testing, assembly level and subsystem testing and inspection shall have been accomplished in accordance with ATP6015497 (ISS Subsystem) and PS2003101 (LGC Group).

4.2.1.3 Output Loading. The output loading required during testing shall be as specified in Table II.

TABLE II

OUTPUT LOADING

SIGNAL		LOAD (ohms)
FDAI	IG AC D/A Error	20K ±5%, 0° ±5°
	MG AC D/A Error	20K ±5%, 0° ±5°
	OG AC D/A Error	20K ±5%, 0° ±5°
	800 cps, 28V, 1% Ref	To be defined
GASTA (TOTAL ATTITUDE)	Sin AIG 1X	415 ±15% +j 1950 ±10%
	Cos AIG 1X	↑
	Sin AMG 1X	↓
	Cos AMG 1X	
	Sin AOG 1X	
	Cos AOG 1X	415 ±15% +j 1950 ±10%
ABORT GUIDANCE SECTION	+1G Delta Theta Abort	500 ±10%
	-1G Delta Theta Abort	↑
	+MG Delta Theta Abort	↓
	-MG Delta Theta Abort	
	+OG Delta Theta Abort	
	-OG Delta Theta Abort	
	CDU Zero	
	AGS Initialization (DNLK Data)	500 ±10%
CAUTION AND WARNING	LGC (Warning)	2.5K ±10% (lamp)
	PGNS (Caution)	
	ISS (Warning)	
ALTITUDE METERS	Altitude Meter 1	200 ±10%
	Altitude Meter 0	↑
	Altitude Rate Meter 1	↓
	Altitude Rate Meter 0	200 ±10%
VELOCITY METERS	Lateral Velocity	120K ±5%
	Forward Meter	120K ±5%

TABLE II (Continued)

SIGNAL		LOAD (ohms)
RENDEZVOUS RADAR	RR Shaft AC D/A Error	20±1K
	RR Trunnion AC D/A Error	20±1K
	Range Gate Strobe	200 ±10%
	Range Rate Gate Strobe	200 ±10%
	Counter Readout Comm	200 ±10%
	Radar Reset Strobe	200 ±10%
LANDING RADAR	XA Velocity Gate Strobe	200 ±10%
	YA Velocity Gate Strobe	↑
	ZA Velocity Gate Strobe	|
	Range Gate Strobe	|
	Counter Readout Comm	|
	Radar Gate Reset Strobe	↓ 200 ±10%
MASTER CLOCK AND TELEMETRY	1024K pps Clock	500 ±10%
	DLNK Data	100 ±10%

4.2.1.4 Inputs. The system shall perform as specified herein with the following inputs.

4.2.1.4.1 Prime Power. The system prime power shall be as specified in Table III.

TABLE III

SYSTEM PRIME INPUT POWER

VOLTAGE*	IDENTIFICATION
+28.0 +5.5, -6 vdc	+28 VDC IMU Standby
+28.0 +5.5, -3.5 vdc	+28 VDC IMU Operate
+28.0 +5.5, -3.5 vdc	+28 VDC LGC
+28.0 +5.5, -3.5 vdc	AOT Heater
115.0±2.5V rms, 400±10 cps	Illumination
2 to 5.5 vdc	Variable Caution Light
2 to 5.5 vdc	Variable Status Light
0 to 75V rms	Variable DSKY
400±10 cps	Illumination
* Values are steady state only	

4.2.1.4.2 Signals. The system input signals shall be as specified in Table IV.

TABLE IV

SYSTEM INPUT SIGNALS

SIGNAL	EXCITATION CHARACTERISTICS
Abort Abort Stage Engine Armed Display Inertial Data Att Control Out of Det Att Hold Mode Stage Verify Auto Throttle Auto Stabilization Thruster pr 4D/4S Fail Thruster pr 3U/3S Fail Thruster pr 4U/4F Fail Thruster pr 3D/3F Fail Thruster pr 1D/1S Fail Thruster pr 1U/1F Fail Thruster pr 2U/2S Fail Thruster pr 2D/2F Fail G&N Control of S/C (Digital Auto Pilot in Control) +EL (LPD) +PMI -EL (LPD) -PMI +AZ (LPD) +RMI -AZ (LPD) -RMI +YMI -YMI +X Trans Comm (Man) -X Trans Comm (Man) +Y Trans Comm (Man) -Y Trans Comm (Man) +Z Trans Comm (Man) -Z Trans Comm (Man) Rate of Descent (+) Rate of Descent (-) Rate of Descent Reset IMU Cage Command Pitch Gimbal Off Roll Gimbal Off LR Range Data Good LR Position 1 (Desc) LR Position 2 (Hover) LR Vel Data Good LR Range Lo Scale RR Data Good RR Range Lo Scale RR PWR ON & in Auto LGC Mode	Switch ON: 17.5±0.5 vdc Switch OFF: 0±2 vdc
Prop Pitch Rate Cmd Prop Roll Rate Cmd Prop Yaw Rate Cmd	See 4.2.1.4.2.1

TABLE IV (Continued)

SIGNAL	EXCITATION CHARACTERISTICS
L Rdr In 0 L Rdr In 1 R Rdr In 0 R Rdr In 1	See 4.2.1.4.2.2
RR Shaft Sin 16X RR Shaft Cos 16X RR Trunnion Sin 16X RR Trunnion Cos 16X	See 4.2.1.4.2.3
RR Shaft Sin 1X RR Shaft Cos 1X RR Trunnion Sin 1X RR Trunnion Cos 1X	See 4.2.1.4.2.4
Dink Start Dink End Dink Sync	See 4.2.1.4.2.5.1
Uplnk "0" Uplnk "1"	See 4.2.1.4.2.5.2
ACE Bias 1 ACE Bias 2	See 4.2.1.4.2.6
Inhibit Power Fail	28.0±4.5 vdc
LR Antenna Pos #1 Auto Angle Track Enable RCS Jet 4D RCS Jet 3D RCS Jet 2D RCS Jet 1D RCS Jet 3U RCS Jet 2U RCS Jet 4U RCS Jet 1U RCS Jet 2S RCS Jet 1S RCS Jet 3S RCS Jet 2F RCS Jet 3F RCS Jet 4F RCS Jet 1F Engine On Asc or Desc Engine Off Asc or Desc + Pitch Trim - Pitch Trim + Roll Trim - Roll Trim	10±1 vdc through a resistive impedance of 2K ±10% ohms 10±1 vdc through a resistive impedance of 2K ±10% ohms

d. Nulls at any position: 10 mv rms in phase max

e. Maximum DC Source Impedance: 200 ohms - each winding

4.2.1.4.2.4 RR 1X Resolver Sine and Cosine (Shaft and Trunnion)

a. Sense: Positive angle rotation - sine and cosine voltages shall be inphase with the reference voltage for the first 90 electrical degrees of resolver rotation.

b. Zero: Resolver electrical zero corresponds to shaft and trunnion zero angle position. The electrical zero occurs when the sine signal goes to null and the cosine signal is near maximum and inphase with the reference excitation signal.

c. Output Form:

(1) Sine: $e_{1s} = E_1 \sqrt{2} \sin(A) \sin(2\pi ft + \phi_1)$

(2) Cos: $e_{1c} = E_2 \sqrt{2} \cos(A) \sin(2\pi ft + \phi_2)$

Where:

$E_1 = E_2 = 28V$ rms ±5 percent

A = Antenna angle

f = Ref Frequency (800 cps ±0.5 percent)

t = Time

ϕ_1 and ϕ_2 = phase shift (5° ±3° with respect to ref voltage)

d. Maximum DC Source Impedance: 300 ohms each winding

4.2.1.4.2.5 LGC Pulse Inputs. The excitation shall provide signal characteristics as follows:

4.2.1.4.2.5.1 Downlink Interface

a. Maximum Source Impedance: 100 ohms
b. Amplitude (A): 4.5±1.0V
c. Pulse Width at A/2 Point: 4±1 microsec
d. Backswing: 0
e. Risetime: 0.3 microsec max. from 10 percent to 90 percent of A
f. Repetition Rate: 50 pps (except sync pulse - 2K pps at 51.2 kc: 40 pulses 50 times per sec.)

g. Timing: (ref to A/2 point) leading edge:

(1) Start to bit sync: 19.5±5.0 μsec
(2) Bit sync to data: 1 μsec max
(3) Stop pulse: 19.5±5.0 μsec after last sync pulse
(4) There shall be 40-bit sync pulses between each start and stop pulse

4.2.1.4.2.5.2 Uplink Interface (UPLINK "0" and UPLINK "1"):

a. Source Impedance: 100 ohms -1; 10 ohms -0 max.
b. Amplitude (A): 7±3V
c. Pulse Width at A/2 Point: 3±1 μsec
d. Droop: 20 percent at 2 μsec
e. Maximum Backswing: 4V
f. Risetime: 0.2 μsec max. from 10 percent to 90 percent of A
g. Repetition Rate: 1K pps
h. Maximum Noise: No pulse - ±0.4V

4.2.1.4.2.6 ACE Bias 1 and 2. A switchable ground shall be supplied to each interface.

4.2.1.4.3 Coolant Requirements

4.2.1.4.3.1 IMU. The IMU shall be provided with water-glycol coolant at a temperature of 40° ±3°F and flow rate of 33±5 lb per hour.

4.2.1.4.3.2 PSA, CDU, PTA Headers. The PSA, CDU, and PTA cold plates shall be provided with coolant sufficient to maintain the header temperature below 70°F.

4.2.1.4.4 Inertial Component Temperature Sensor Current:

a. PIPA 6±0.12 ma dc
b. IRIG 2±0.04 ma dc

4.2.1.5 Test Data. All system test data shall be recorded on suitable reproducible forms and stored at the contractor's facility. Copies of the recorded data shall accompany the system. Where space is provided to indicate the value or specific reading obtained, the specific reading shall be recorded if a limit or limits is given for a test. Further, the initials of the individual performing the inspection shall be inserted above the value observed and recorded. If limits are not stated, it is required that the individual performing the test initial in the space provided indicating that the requirements were met.

4.2.1.6 Test Values. All test values given in Section 4 of this specification reflect allowances for instrumentation error, loads, or variation in supply voltages and frequencies.

4.2.1.7 Safety Precautions. Normal safety precautions required during testing of precision electromechanical equipment shall be followed. The following requirements shall be observed [illegible] lines of the GSE with the GSN system power applied.

4.2.1.8 Operational Precautions

4.2.1.8.1 G&N System Turn-On. The following conditions shall be met prior to IMU power application.

4.2.1.8.1.1 Initial Turn-On. If the IMU has just been installed in the test fixture, LGC power shall be applied with the IMU Standby power for a minimum of two hours.

4.2.1.8.1.2 General Turn-On. If the IMU Operate power has been applied to the G&N System through normal JDC procedures specified in Figure 2 and the IMU gimbals have been parked not in excess of five days or have not been moved since parking, LGC power shall be applied with the IMU Standby power for a minimum of fifteen minutes. If the IMU gimbals have not been parked, an equivalent minute for minute waiting period with LGC and IMU Standby power applied shall be endured. If the waiting period is in excess of two hours, a two hour waiting period shall suffice. If the GSE temperature controller has been allowed to maintain an IRIG temperature greater than 135°F a minimum waiting period of thirty minutes shall be endured.

4.2.1.8.2 G&N System Turn-Off. The following conditions shall be strictly adhered to prior to removal of G&N System power at the interface:

4.2.1.8.2.1 IMU Gimbal Parking. The IMU gimbals shall be positioned such that the PIPA and IRIG output axes are horizontal ±5°.

4.2.1.8.2.2 Power Turn-Off Sequence. Upon G&N System power removal, the IMU Operate power shall be turned off first. The IMU Standby and LGC power may then be turned off in that order.

4.2.1.8.3 Suspension Power. The LGC power (3200 cps suspension power) shall not be off while torquing the inertial components is taking place. Noncompliance shall result in degaussing and recalibration of the components.

4.2.1.8.4 Gimbal Lock. A Verb 36 shall be entered into the DSKY if the IMU Middle Gimbal is coarse aligned to within the gimbal lock limits greater than ±70°.

4.2.1.8.5 Inertial Component Performance Tests. The IMU Operate power must be applied for a minimum of one hour prior to performing JDC 12624.

4.2.1.9 Test Equipment Required. The test equipment utilized in whole or part as required by the respective JDC for the test being conducted shall be in accordance with Drawing 1900030.

4.2.1.10 Jigs and Fixtures. Test probes shall not be used to make direct electrical connections to connectors of the Apollo Guidance Equipment. Jigs made up of mating connectors shall be used.

4.2.1.11 Rotary Table Alignment Requirements. The Rotary Table Tilt axis shall be aligned parallel to true east within ±1 minute, and at 0° tilt the rotary axis shall be aligned within ±2 seconds of vertical.

4.2.1.11.1 Fixture Alignment and Calibration Procedures. The procedures shall be conducted in accordance with the following JDC's.

JDC 16010	Rotary Table Leveling Calibration Test
JDC 16011	IMU Mounting Fixture Alignment Test about the X and Y Axes
JDC 16012	IMU Mounting Fixture Alignment Test about the Z axis

The rotary axis and tilt axis calibrations shall be accomplished at 3 month intervals, in accordance with the following JDC's.

JDC 19728	Rotary Tilt and Rotary Axis Calibration

4.2.1.12 Test Setup. The APOLLO G&N equipment shall be tested and inspected under the test conditions specified herein.

4.2.1.12.1 Assembly Requirements. The G&N System shall be assembled to the G&N Ground Support Equipment and the assembly and test equipment interconnect procedures shall be conducted in accordance with the following JDC's:

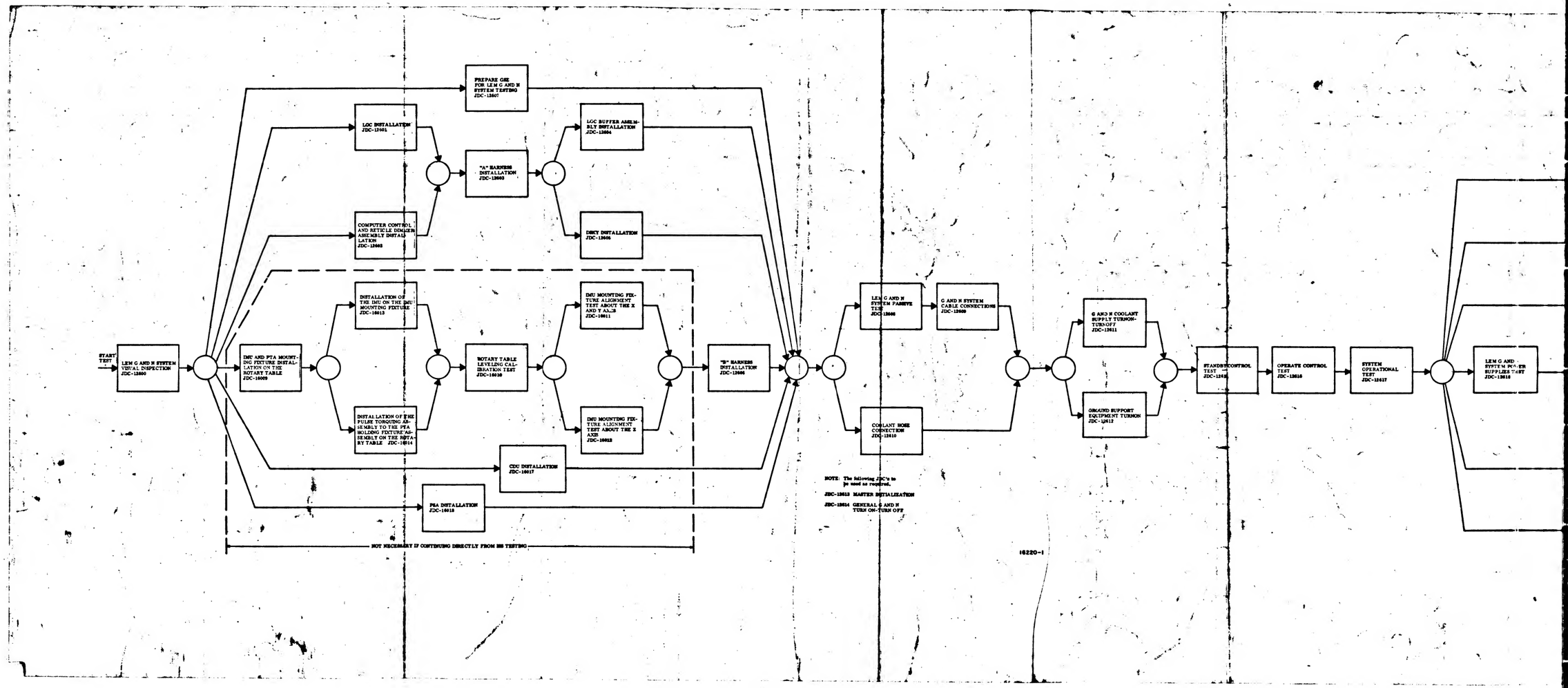
JDC	DESCRIPTION
12600	LEM G&N System Visual Inspection
12601	LGC Installation
12602	Computer Control and Reticle Dimmer Assembly Installation
12603	"A" Harness Installation
12604	LGC Buffer Assembly Installation
12605	DSKY Installation
12606	"B" Harness Installation
12608	LEM G&N System Passive Test
12610	Coolant Hose Connection
12611	G&N Coolant Supply Turnon-TurnOff
16009	IMU & PTA Mounting Fixture Installation on the Rotary Table
16013	Installation of the IMU on the IMU Mounting Fixture
16014	Installation of the pulse torquing Assembly to the PTA Holding Fixture Assembly on the Rotary Table
16017	CDU Installation
16018	PSA Installation

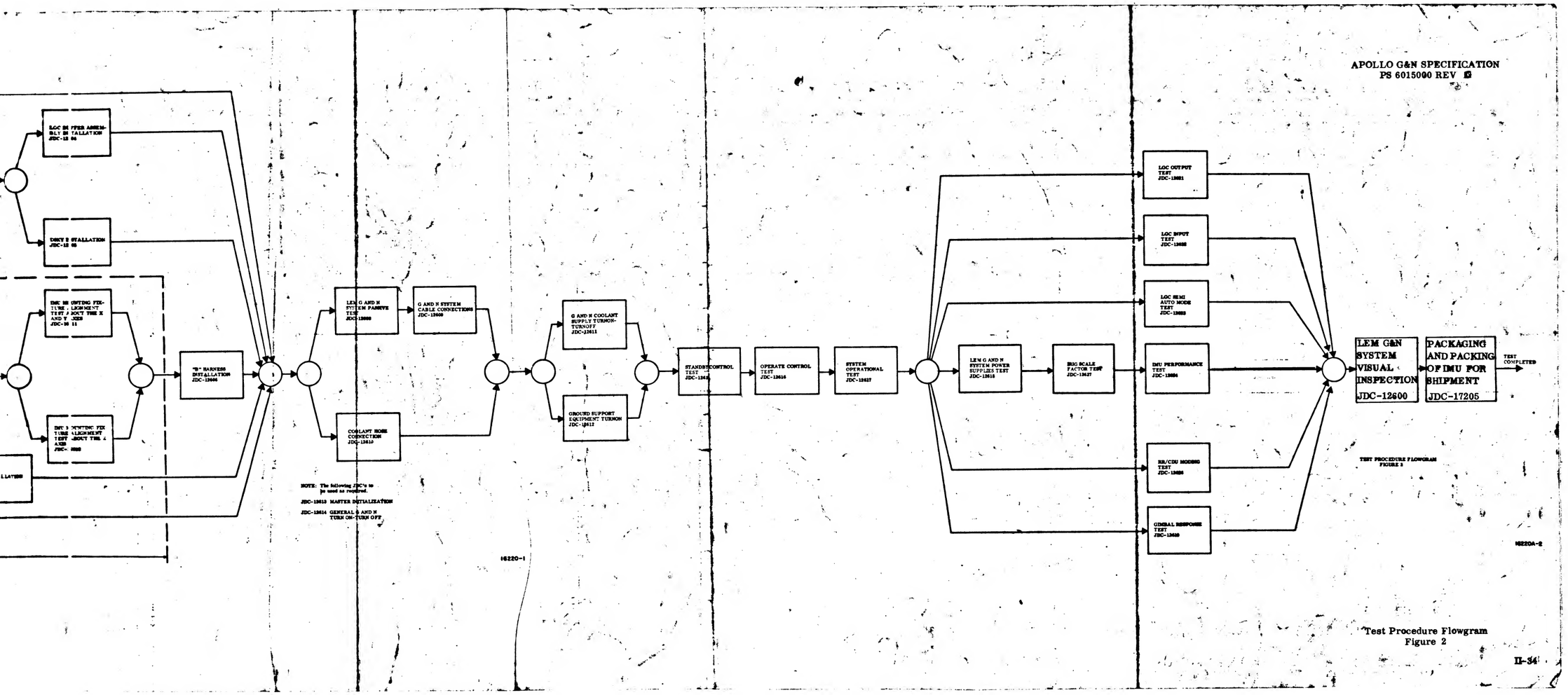
4.2.1.13 Test Sequence. The sequence of operations shall be as specified in Figure 2.

4.2.2 Nonconforming Units. Failure of the system to pass any examination or test of this specification shall automatically classify the unit as nonconforming. Each nonconforming unit corrected shall be reinspected. Reinspection may be limited to the test or examination which defined the nonconformance, or, when directed by the cognizant inspector, a complete retest and reexamination may be required. Nonconforming units which have not been corrected will be considered for acceptance only upon formal application by the contractor to the cognizant NASA representative.

4.3 TESTS

4.3.1 Applicable JDC's. The JDC's specified in the index of 4.1 form the acceptance test procedures of this specification.


PREPARE GSE FOR LEM G AND N SYSTEM TESTING JDC-13607
LGC INSTALLATION JDC-13601
"A" HARNESS INSTALLATION JDC-13602
LGC BUFFER ASSEMBLY INSTALLATION JDC-13604
COMPUTER CONTROL AND RETICLE DIMMER ASSEMBLY INSTALLATION JDC-13603
DSKY INSTALLATION JDC-13605
INSTALLATION OF THE IMU ON THE IMU MOUNTING FIXTURE JDC-16013
IMU MOUNTING FIXTURE ALIGNMENT TEST ABOUT THE X AND Y AXES JDC-16011
START TEST
LEM G AND N SYSTEM VISUAL INSPECTION JDC-13600
IMU AND PIA MOUNTING FIXTURE INSTALLATION ON THE ROTARY TABLE JDC-16009
ROTARY TABLE LEVELING CALIBRATION TEST JDC-16010
"B" HARNESS INSTALLATION JDC-13606
LEM G AND N SYSTEM PASSIVE TEST JDC-13608
G AND N SYSTEM CABLE CONNECTIONS JDC-13609
G AND N COOLANT SUPPLY TURNON-TURN-OFF JDC-13611
INSTALLATION OF THE PULSE TORQUING ASSEMBLY TO THE PIA HOLDING FIXTURE ASSEMBLY ON THE ROTARY TABLE JDC-16014
IMU MOUNTING FIXTURE ALIGNMENT TEST ABOUT THE Z AXIS JDC-16012
COOLANT HOSE CONNECTION JDC-13610
GROUND SUPPORT EQUIPMENT TURNON JDC-13612
STANDBY CONTROL TEST JDC-13614
OPERATE CONTROL TEST JDC-13615
SYSTEM OPERATIONAL TEST JDC-13617
LEM G AND SYSTEM POWER SUPPLIES TURNOFF JDC-13618
CDU INSTALLATION JDC-16017
PIA INSTALLATION JDC-16018
NOT NECESSARY IF CONTINUING DIRECTLY FROM SS TESTING
NOTE: The following JDC's to be used as required.
JDC-13613 MASTER INITIALIZATION
JDC-13614 GENERAL G AND N TURN ON-TURN OFF
16220-1



Test Procedure Flowgram
Figure 2

5. PREPARATION FOR DELIVERY

5.1 GENERAL. With the exception of the IMU, preparation for delivery shall be in accordance with Specification ND1002214.

5.2 IMU Preparation for Shipment. The Inertial Measurement Unit shall be prepared for shipment in accordance with JDC17208, Packaging and Packing of IMU for Shipment.

6. NOTES. (To be supplied)

6.1 DEFINITIONS AND ABBREVIATIONS

3. REQUIREMENTS

3.1 PERFORMANCE

3.1.1 Standby Control

3.1.1.1 LEM Standby Mode. The following requirements shall be met with the IMU in the standby condition.

3.1.1.1.1 28 VDC IMU Standby. The IMU Standby voltage shall be 22.0±1.0 vdc.

3.1.1.1.2 Inertial Component Temperature. The mean stabilized PIPA temperature shall be 130.5±1.5°F within 1 hour after entering the Standby Mode. The mean stabilized IRIG temperature shall be within 3.0°F of the PIPA temperature.

3.1.1.2 G&N Standby Mode (LGC STBY). The following requirements shall be met with the IMU in the standby condition and the LGC in the standby condition.

3.1.1.2.1 28 VDC IMU Standby. The IMU Standby voltage shall be 28.0±1.0 vdc.

3.1.1.2.2 3200 cps Suspension Power. The 3200 cps suspension voltage shall be 28.6±0.56 volts rms at a frequency of 3200±1 cps.

3.1.1.2.3 Master Clock Sync. The Master Clock Sync signal characteristics shall be as follows. (See Figure 1).

a. Amplitude: 4.0 volts minimum.
b. Pulse Width: 0.50±0.25 microseconds.
c. Rise Time: 0.2 microseconds max. from 10 to 90 percent of amplitude.
d. Frequency: 1024K pps ±2 ppm over a 15 minute period.

3.1.1.3 G&N Standby Mode(LGC Operate). The following requirements shall be met with the IMU in the standby condition, the LGC in the operate condition, and the LGC +4 and +14 volt dc power supplies at 4.0±0.20 and 14.0±0.4, respectively.

3.1.1.3.1 LGC Voltage Fail Alarm Limits. A Voltage Fail alarm shall occur as indicated by the presence of a LGC Warning discrete, at a voltage within each of the following power supply output limits. The following occurs:

Power Supply	Low Alarm Limits (vdc)	High Alarm Limits (vdc)
a. +4 vdc	3.65±0.15 vdc	4.40±0.20
b. +14 vdc	12.5±0.30 vdc	16.0±0.40
c.		

The LGC ALARM CONDITION lamp shall not illuminate when the +4 vdc power supply is 3.80 vdc to 4.20 vdc or when the +14 vdc power supply is 12.80 vdc to 15.60 vdc.

3.1.1.3.2 Inhibit Power Fail. The LGC shall exhibit no failures with the Inhibit Power Fail discrete present.

3.1.1.3.3 Voltage Margin Requirements. No LGC failure indication shall occur under the following conditions with the Inhibit Power Fail discrete present.

a. The +4 vdc supply shall be varied from a maximum low of 3.4 vdc to a maximum high of 4.6 vdc with the +14 vdc supply held at 12.1 vdc nominally and at 16.4 vdc nominally.

b. The +14 vdc supply shall be varied from a maximum low of 12.1 vdc to a maximum high of 16.4 vdc with the +4 vdc supply held at 3.40 vdc nominally and at 4.6 vdc nominally.

3.1.1.4 Reticle Lamp Voltage. The variable AOT Reticle Lamp Voltage shall have the following characteristics at the interface:

a. Minimum Voltage: less than -0.27 vdc
b. Maximum Voltage: -4.67 vdc

3.1.2 Operate Control

3.1.2.1 IMU Operate Delay Indication. LGC Channel 30 shall indicate a "0" in bit 14 when the system is supplied with the +28.0±0.5 VDC IMU Operate power and shall remain in the "0" state for 90±5 seconds after which time bit 14 of Channel 30 and bit 15 of Channel 12 shall indicate a "1".

3.1.2.1.1 Inertial Component Pulse Torquing. During the 90 second delay period, the IRIG and PIPA pulse torque power supply shall be inhibited. Loss of +28 VDC LGC prime power shall result in the same condition.

3.1.2.1.2 Automatic Caging and CDU Ambiguity Operation. The IMU gimbal resolvers shall drive until the 1X sine signals indicate 0.00±0.50 volts rms and the 1X cosine signals indicate 26.0±2.6 volts rms, with the IMU gimbal angles initially at 225°.

3.1.2.2 Inertial Component Temperature. The following requirements shall be met in the Operate mode with IMU gimbals coarse aligned to 0° ±5°.

3.1.2.2.1 Standby to Operate Transient. The PIPA temperature, during the first 15 minutes after switching from the Standby mode to the Operate mode, shall be within 0.5°F of the temperature specified in 3.1.1.1.2. At 15 minutes the PIPA temperature shall be within 0.5°F of its stabilized value. At 30 minutes the IRIG temperature shall be within 0.5°F of its stabilized value.

3.1.2.2.2 Inertial Component Temperature Control Point. The stabilized values of the PIPA and IRIG temperatures shall be 130.5±1.5°F and 135±2.5°F, respectively. The stabilized PIPA temperature shall be within 1.0°F of the stabilized PIPA temperature measured in 3.1.1.1.2. The temperature shall be considered stabilized when the temperature change is less than 0.1°F for 30 minutes.

3.1.2.2.3 Heater Telemetry Discrete. The Heater Telemetry Discrete shall cycle ON and OFF. The ON state shall be 0±5 vdc and the OFF state shall be 26.5±7.0 vdc, at the interface.

3.1.2.2.4 Blower Telemetry Discrete. The Blower Telemetry Discrete shall cycle ON and OFF with a heater duty cycle of approximately 45 percent. The ON state shall be 0±5V rms and the OFF state shall be 28.0±2.8V rms.

NOTE: With the operating parameters given in this specification, the blowers will always be on.

3.1.2.3 800 CPS Power Supply Temperature. The resistance of the temperature thermistor shall be 2.21K to 8.37K ohms.

3.1.2.4 Temperature Monitor 1. The resistance of the temperature thermistor shall be 1.4K to 13.25K ohms.

3.1.2.5 Calibration Module Temperature. The resistance of the temperature thermistor shall be 3.65K to 13.25K ohms.

3.1.2.6 +28 VDC IMU Operate. The IMU Operate voltage shall be 28.5+0, -1 vdc.

3.1.3 System Power Supplies. The system power supplies shall meet the following requirements.

3.1.3.1 IMU 28V, 1 Percent, 800 CPS Supply

3.1.3.1.1 Voltage. The output voltage shall be 28.00±0.56V rms.

3.1.3.1.2 Frequency. The output frequency shall be 800±1 cps.

3.1.3.2 IMU 28V, 5 Percent, 800 CPS Supplies (Phases A and B)

3.1.3.2.1 Voltage. The output voltage of phase A shall be 28.0±1.4V rms and the output voltage of phase B shall be 28.0±2.1V rms.

3.1.3.2.2 Frequency. The frequency of the power supply outputs shall be 800±1 cps.

3.1.3.2.3 Phase. The output of the phase A supply shall be -90° ±10° with respect to the IMU 28V, 1 percent power supply output. The output of the phase B supply shall be -90° ±10° with respect to the IMU 28V, 5 percent, phase A power supply output.

c. KEY REL: shall illuminate by presence of a "1" in bit 5 of CH 11

d. GIMBAL LOCK: shall illuminate by presence of a "1" in bit 6 of RLYWD 1100 as a result of the MIDDLE gimbal CDU indicating angles between +07000 and +29000 as verified by interrogation of the first counter address (00034) in the LGC.

e. TEMP: shall illuminate by presence of a "1" in bit 4 of CH 11.

f. PROG: shall illuminate by presence of a "1" in bit 9 of RLYWD 1100 subsequent to an illegal program function or PIPA FAIL.

g. RESTART: shall only illuminate as a result of any or all of the following conditions:

(1) STANDBY
(2) TC TRAP
(3) RUPT LOCK
(4) PARITY FAIL
(5) NIGHT WATCHMAN
(6) VOLTAGE FAIL

h. TRACKER: shall illuminate by presence of a "1" in bit 8 of RLYWD 1100.

i. OPR ERR: (Flashing) shall illuminate by presence of a "1" in bit 7 of CH 11.

j. COMP ACTY: shall illuminate by presence of a "1" in bit 2 of CH 11.

k. UPLINK ACTY: shall illuminate by presence of a "1" in bit 3 of CH 11.

m. Electro-luminescent Elements: The following numeric displays shall illuminate by program or DSKY stimuli or both.

(1) PROG
(2) VERB } Flashing when program stimulation causes the presence
(3) NOUN } of a "1" in bit 6 of Channel 11.
(4) REGISTER 1
(5) REGISTER 2
(6) REGISTER 3

3.1.4.4 LGC Commands to Reaction Control System (RCS). With a "1" in the following bit assignments, a voltage of 3 to 6 vdc shall be present at the interface. With a "0" in the following bit assignments, a voltage of 9.6±0.6 vdc shall be present at the interface.

Channel 5	Bit No.	Channel 5	Bit No.
+X RCS Jet 4D	2	-X RCS Jet 4U	1
+X RCS Jet 3D	4	-X RCS Jet 3U	3
+X RCS Jet 2D	6	-X RCS Jet 2U	5
+X RCS Jet 1D	8	-X RCS Jet 1U	7

3.1.7.2 PIPA Bias. The PIPA bias in a 1g field shall not exceed 3.10 cm/sec^2 maximum limit and shall conform to the stability requirements of 3.1.14.

3.1.8 Stabilization Loops

3.1.8.1 Step Response. The IRIG floats shall be initially displaced from electrical null by application of 10, 5 and 5 vdc ±5 percent to the test inputs of the respective Inner, Middle and Outer gimbal DC Amplifiers and shall return to null upon removal of this voltage. The time interval between the removal of this disturbance and the settling to within 5 percent of steady state values shall not exceed 0.1 second. The inner and middle gimbal error signals shall have a maximum of 3 oscillation peaks outside the 5 percent tolerance band. The outer gimbal error signal shall have a maximum of 5 oscillation peaks outside the 5 percent tolerance band.

3.1.8.2 Gimbal Torque Level. The friction level of each gimbal, when torqued by its IRIG shall not exceed 26.2 in-oz, indicated by a peak torque motor current not exceeding 0.125 amps.

3.1.9 IRIG Drift Coefficients

3.1.9.1 NBD. The IRIG bias drift (NBD) shall not exceed 15.0 meru maximum limit and shall conform to the stability requirements of paragraph 3.1.14.

3.1.9.2 ADIA. The IRIG drift due to acceleration along the input axis (ADIA) shall not exceed 100 meru/g maximum limit and shall conform to the stability requirements of 3.1.14.

3.1.9.3 ADSRA. The IRIG drift due to acceleration along the spin reference axis (ADSRA) shall not exceed 40 meru/g maximum limit and shall conform to the stability requirements of 3.1.14.

3.1.10 IRIG Scale Factor. The IRIG pulse torque scale factor shall be 2π radians/2^{21} pulses ±1750 ppm.

3.1.11 System Fine Alignment Accuracy. The stable member (SM) as defined by the X, Y and Z PIPA input axes shall be aligned to predetermined orientations with respect to the AOT LOS with a maximum error of 600 arc seconds about any PIPA input axis as accomplished by an LGC alignment. The maximum error shall not include the PIPA bias terms.

NOTE: This is a Post S/C Installation Test Requirement only.)

3.1.12 Abort Guidance System

3.1.12.1 Gimbal Angle Transmission Accuracy. A plus and minus gimbal angle increment (ΔA) about each axis shall be commanded by the LGC. A total pulse count of ΔA (0.01098) ±1 pulse shall be present on the plus and minus $\Delta\theta$ abort signals.

3.1.12.1.1 Pulse Characteristics of $\Delta\theta$ Abort Signals. With a constant rate of change of the $\Delta\theta$ Abort pulse commanded by the LGC, the pulse characteristics of the $\Delta\theta$ Abort signals shall be as follows. (See Figure 1).

a. Amplitude (A): 7±3 volts peak
b. Risetime: 0.5 microseconds at 10% to 90% of A
c. Pulse Width: 3.0±1.0 microseconds at 50% of A
d. Droop: 20% of A max
e. No Pulse Amplitude: -4.0 volts min to +4 volts max with reference to the zero vdc reference.

4.2.1.8 Operational Precautions

4.2.1.8.1 G&N System Turn-On. The following conditions shall be met prior to IMU power application.

4.2.1.8.1.1 Initial Turn-On. If the IMU has just been installed in the test fixture, LGC power shall be applied with the IMU Standby power for a minimum of two hours.

4.2.1.8.1.2 General Turn-On. If the IMU Operate power has been applied to the G&N System through normal JDC procedures specified in Figure 2 and the IMU gimbals have been parked not in excess of five days or have not been moved since parking, LGC power shall be applied with the IMU Standby power for a minimum of fifteen minutes. If the IMU gimbals have not been parked, an equivalent minute for minute waiting period with LGC and IMU Standby power applied shall be endured. If the waiting period is in excess of two hours, a two hour waiting period shall suffice. If the GSE temperature controller has been allowed to maintain an IRIG temperature greater than 135°F a minimum waiting period of thirty minutes shall be endured.

4.2.1.8.2 G&N System Turn-Off. The following conditions shall be strictly adhered to prior to removal of G&N System power at the interface.

4.2.1.8.2.1 IMU Gimbal Parking. The IMU gimbals shall be positioned such that the PIPA and IRIG output axes are horizontal ±5°.

4.2.1.8.2.2 Power Turn-Off Sequence. Upon G&N System power removal, the IMU Operate power shall be turned off first. The IMU Standby and LGC power may then be turned off in that order.

4.2.1.8.3 Suspension Power. The LGC power (3200 cps suspension power) shall not be off while torquing the inertial components is taking place. Noncompliance shall result in degaussing and recalibration of the components.

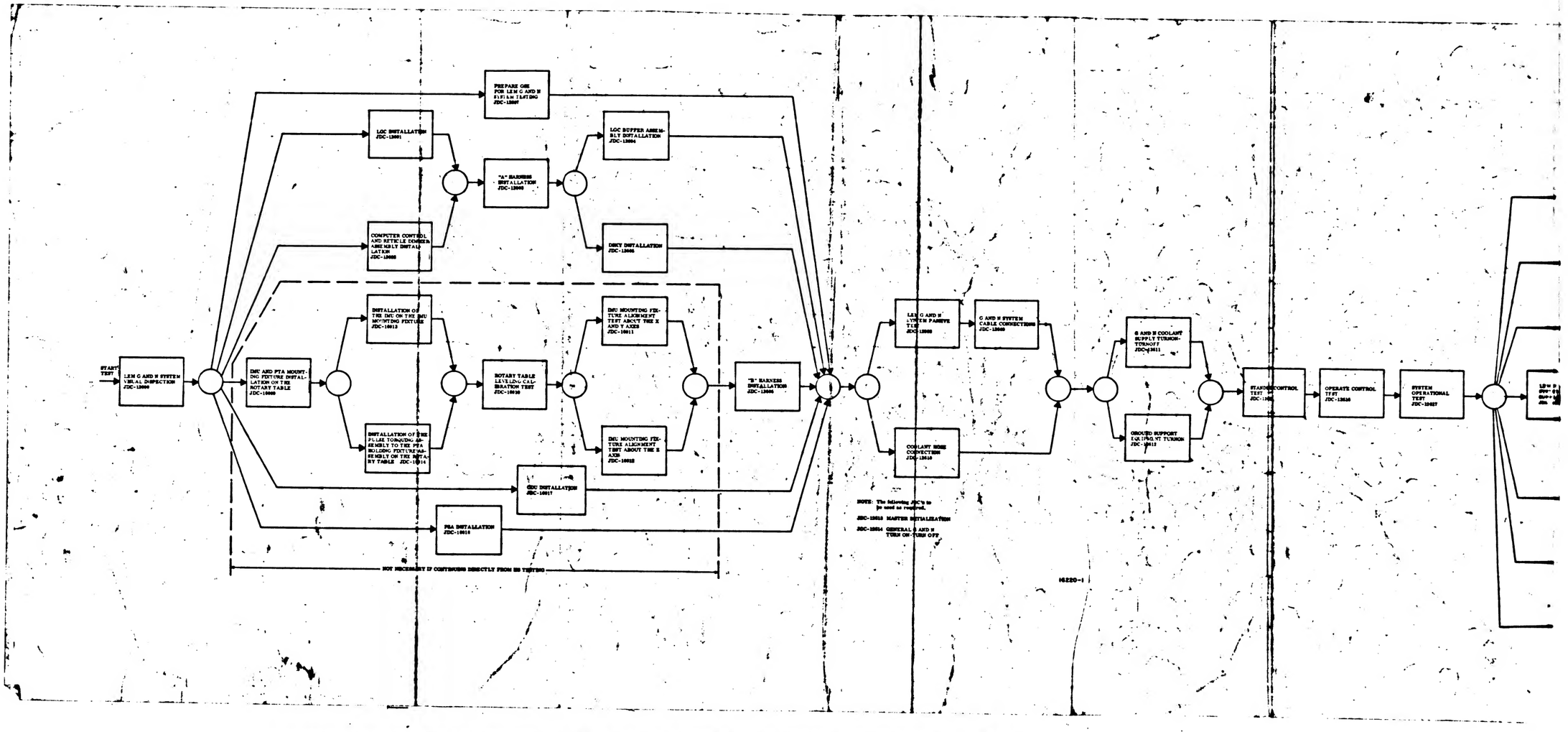
4.2.1.8.4 Gimbal Lock. A Verb 36 shall not be entered into the DSKY if the GIMBAL LOCK lamp is lighted, i.e. within the gimbal lock limits greater than ±70°.

4.2.1.8.5 Inertial Component Performance Tests. The IMU Operate power must be applied for a minimum of one hour prior to performing JDC 12624.

4.2.1.9 Test Equipment Required. The test equipment utilized in whole or part as required by the respective JDC for the test being conducted shall be in accordance with Drawing 1900030.

4.2.1.10 Jigs and Fixtures. Test probes shall not be used to make direct electrical connections to connectors of the Apollo Guidance Equipment. Jigs made up of mating connectors shall be used.

4.2.1.11 Rotary Table Alignment Requirements. The Rotary Table Tilt axis shall be aligned parallel to true east within ±1 minute, and at 0° tilt the rotary axis shall be aligned within ±2 seconds of vertical.



APOLLO G&N Specification
PS6015000 REV J
Original Issue Date:
Release Authority: TDRR 2534
Class A Release
CODE IDENT NO. 80230

MASTER END ITEM DETAIL SPECIFICATION

PART II

PRODUCT CONFIGURATION AND ACCEPTANCE TEST REQUIREMENTS

PGNCS SPACECRAFT EQUIPMENT

LEM

DRAWING NO. 6015000

MEI NO. 6015000

Record of Revisions

Date	Revision Letter	TDRR No.	Pages Revised	Approvals AC	Approvals NASA
3/16/66	A	27208	4, 6-33 now 34 pages was 33.	WK	TM
3/18/66	B	27091	33	WK	TM
6/28/66	C	29846	4, 6, 7, 8, 11, 13, 15, 17, 18, 23,		
			30, 31, 32	MGM	ACM
9/28/66	D	31247	7, 17, 18, 19, 24	MGM EA	WLS
11/1/66	E	31734	33, 34	MGM EA	WLS
12/29/66	F	32463	4, 6-10, 14, 15, 18, 20	MGM JP	RJJ
3/23/67	G	33218	6, 7, 19-35. Specification was	MGM EA	WLS
			34 pages, now 35 pages.		
11/30/67	H	35161	4, 6, 7, 10, 20, 21, 32, 34	MGM EA	WLS
4/25/68	J	36130	4, 6, 26	MGM EA	WLS

This specification consists of page 1 to 35 inclusive.

APPROVALS	NASA/MSC	MIT/IL	AC

3. REQUIREMENTS

3.1 PERFORMANCE

3.1.1 Standby Control

3.1.1.1 LEM Standby Mode. The following requirements shall be met with the IMU in the standby condition.

3.1.1.1.1 28 VDC IMU Standby. The IMU Standby voltage shall be 22.0±1.0 vdc.

3.1.1.1.2 Inertial Component Temperature. The PIPA temperature after stabilization in Standby shall be within 1.0° F of the temperature recorded in 3.1.2.2.2. The temperature shall be considered stabilized when the temperature change is less than 0.1° F for 30 minutes.

3.1.1.2 G&N Standby Mode (LGC STBY). The following requirements shall be met with the IMU in the standby condition and the LGC in the standby condition.

3.1.1.2.1 28 VDC IMU Standby. The IMU Standby voltage shall be 28.0±1.0 vdc.

3.1.1.2.2 3200 cps Suspension Power. The 3200 cps suspension voltage shall be 28.6±0.56 volts rms at a frequency of 3200±1 cps.

3.1.1.2.3 Master Clock Sync. The Master Clock Sync signal characteristics shall be as follows. (See Figure 1).

a. Amplitude: 4.0 volts minimum.
b. Pulse Width: 0.50±0.25 microseconds.
c. Rise Time: 0.2 microseconds max. from 10 to 90 percent of amplitude.
d. Frequency: 1024K pps ±2 ppm over a 15 minute period.

3.1.1.3 G&N Standby Mode(LGC Operate). The following requirements shall be met with the IMU in the standby condition, the LGC in the operate condition, and the LGC +4 and +14 volt dc power supplies at 4.0±0.20 and 14.0±0.4, respectively.

3.1.1.3.1 LGC Voltage Fail Alarm Limits. A Voltage Fail alarm shall occur as indicated by the presence of a LGC Warning discrete at a voltage within each of the following power supply output limits: (Following [illegible])

Power Supply	Low Alarm Limits (vdc)	High Alarm Limits (vdc)
a. +4 vdc [illegible] vdc	+3.65±0.15 [illegible]	4.40±0.20
b. +14 vdc [illegible] vdc	12.5±0.30 [illegible]	16.0±0.40

The LGC ALARM CONDITION lamp shall not illuminate when the +4 vdc power supply is 3.80 vdc to 4.20 vdc or when the +14 vdc power supply is 12.80 vdc to 15.60 vdc.

3.1.1.3.2 Inhibit Power Fail. The LGC shall exhibit no failures with the Inhibit Power Fail discrete present.

3.1.1.3.3 Voltage Margin Requirements. No LGC failure indication shall occur under the following conditions with the Inhibit Power Fail discrete present.

a. The +4 vdc supply shall be varied from a maximum low of 3.4 vdc to a maximum high of 4.6 vdc with the +14 vdc supply held at 12.1 vdc nominally and at 16.4 vdc nominally.

b. The +14 vdc supply shall be varied from a maximum low of 12.1 vdc to a maximum high of 16.4 vdc with the +4 vdc supply held at 3.40 vdc nominally and at 4.6 vdc nominally.

3.1.1.4 Reticle Lamp Voltage. The variable AOT Reticle Lamp Voltage shall have the following characteristics at the interface:

a. Minimum Voltage: less than 0.30V rms true
b. Maximum Voltage: 4.9±0.3V rms true

3.1.2 Operate Control

3.1.2.1 IMU Operate Delay Indication. LGC Channel 30 shall indicate a "0" in bit 14 when the system is supplied with the +28.0±0.5 VDC IMU Operate power and shall remain in the "0" state for 90±5 seconds after which time bit 14 of Channel 30 and bit 15 of Channel 12 shall indicate a "1".

3.1.2.1.1 Inertial Component Pulse Torquing. During the 90 second delay period, the IRIG and PIPA pulse torque power supply shall be inhibited. Loss of +28 VDC LGC prime power shall result in the same condition.

3.1.2.1.2 Automatic Caging and CDU Ambiguity Operation. The IMU gimbal resolvers shall drive until the 1X sine signals indicate 0.00±0.50 volts rms and the 1X cosine signals indicate 26.0±2.6 volts rms, with the IMU gimbal angles initially at 225°.

3.1.2.2 Inertial Component Temperature. The following requirements shall be met in the Operate mode with IMU gimbals coarse aligned to 0° ±5°.

3.1.2.2.1 Standby to Operate Transient. The PIPA temperature during the first 15 minutes after switching from Standby mode to the Operate mode shall be 130.5° F ±2.0° F. The PIPA temperature after 15 minutes in Operate shall be within 0.5° F of the temperature recorded in 3.1.2.2.2. The IRIG temperature after 30 minutes in Operate shall be within 0.5° F of the temperature recorded in 3.1.2.2.2.

3.1.2.2.2 Inertial Component Temperature Control Point. The PIPA temperature shall be 130.5±1.5° F after stabilization in Operate. The IRIG temperature shall be 135±2.5° F after stabilization in Operate. The temperature shall be considered stabilized when the temperature change is less than 0.1° F for 30 minutes.

3. REQUIREMENTS

3.1 PERFORMANCE

3.1.1 Standby Control

3.1.1.1 LEM Standby Mode. The following requirements shall be met with the IMU in the standby condition.

3.1.1.1.1 28 VDC IMU Standby. The IMU Standby voltage shall be 28.0±1.0 vdc.

3.1.1.1.2 Inertial Component Temperature. The PIPA temperature after stabilization in Standby shall be within 1.0° F of the temperature recorded in 3.1.2.2.2. The temperature shall be considered stabilized when the temperature change is less than 0.1° F for 30 minutes.

3.1.1.2 G&N Standby Mode (LGC STBY). The following requirements shall be met with the IMU in the standby condition and the LGC in the standby condition.

3.1.1.2.1 28 VDC IMU Standby. The IMU Standby voltage shall be 28.0±1.0 vdc.

3.1.1.2.2 3200 cps Suspension Power. The 3200 cps suspension voltage shall be 28.6±0.56 volts rms at a frequency of 3200±1 cps.

3.1.1.2.3 Master Clock Sync. The Master Clock Sync signal characteristics shall be as follows. (See Figure 1.)

a. Amplitude: 4.0 volts minimum.
b. Pulse Width: 0.50±0.25 microseconds.
c. Rise Time: 0.2 microsecconds max from 10 to 90 percent of amplitude.
d. Frequency: 1024K pps ±2 ppm over a 15 minute period.

3.1.1.3 G&N Standby Mode (LGC Operate). The following requirements shall be met with the IMU in the standby condition, the LGC in the operate condition, and the LGC +4 and +14 volt dc power supplies at 4.0±0.20 and 14.0±0.4, respectively.

3.1.1.3.1 LGC Voltage Fail Alarm Limits. The LGC ALARM CONDITION lamp shall illuminate when either the +4 vdc power supply output is greater than 4.60 vdc or less than 3.50 vdc and/or when the +14 vdc power supply is greater than 16.4 vdc or less than 12.2 vdc. The LGC ALARM CONDITION lamp shall not illuminate when the +4 vdc power supply output is 3.80 vdc to 4.20 vdc and when the +14 vdc power supply output is 12.80 vdc to 15.60 vdc. The LGC ALARM CONDITION lamp state is unspecified in voltage regions other than those specified above.

3.1.1.3.2 Inhibit Power Fail. The LGC shall exhibit no failures with the Inhibit Power Fail discrete present.

3.1.1.3.3 Voltage Margin Requirements. No LGC failure indication shall occur under the following conditions with the Inhibit Power Fail discrete present.

a. The +4 vdc supply shall be varied from 3.4 VDC to 4.9 VDC with the +16 VDC supply held at 12.1 VDC nominally and at 16.4 VDC nominally.

b. The +14 vdc supply shall be varied from 12.1 VDC to 16.4 VDC with the +4 VDC supply held at 3.4 VDC nominally and at 4.5 VDC nominally and at 4.6 vdc nominally.

3.1.1.4 Reticle Lamp Voltage. The variable AOT Reticle Lamp Voltage shall have the following characteristics at the interface:

a. Minimum Voltage: less than 0.30V rms true
b. Maximum Voltage: 4.9±0.3V rms true

3.1.2 Operate Control

3.1.2.1 IMU Operate Delay Indication. LGC Channel 30 shall indicate a "0" in bit 14 when the system is supplied with the +28.0±0.5 VDC IMU Operate power and shall remain in the "0" state for 90±5 seconds after which time bit 14 of Channel 30 and bit 15 of Channel 12 shall indicate a "1".

3.1.2.1.1 Inertial Component Pulse Torquing. During the 90 second delay period, the IRIG and PIPA pulse torque power supply shall be inhibited. Loss of +28 VDC LGC prime power shall result in the same condition.

3.1.2.1.2 Automatic Caging and CDU Ambiguity Operation. The IMU gimbal resolvers shall drive until the 1X sine signals indicate 0.00±0.50 volts rms and the 1X cosine signals indicate 26.0±2.6 volts rms, with the IMU gimbal angles initially at 225°.

3.1.2.2 Inertial Component Temperature. The following requirements shall be met in the Operate mode with IMU gimbals coarse aligned to 0° ±5°.

3.1.2.2.1 Standby to Operate Transient. The PIPA temperature during the first 15 minutes after switching from Standby mode to the Operate mode shall be 130.5° F ±2.0° F. The PIPA temperature after 15 minutes in Operate shall be within 0.5° F of the temperature recorded in 3.1.2.2.2. The IRIG temperature after 30 minutes in Operate shall be within 0.5° F of the temperature recorded in 3.1.2.2.2.

3.1.2.2.2 Inertial Component Temperature Control Point. The PIPA temperature shall be 130.5±1.5° F after stabilization in Operate. The IRIG temperature shall be 135±2.5° F after stabilization in Operate. The temperature shall be considered stabilized when the temperature change is less than 0.1° F for 30 minutes.

Test/Examination	Requirement	JDC Method
PGNCS Caution	3.1.4.14	12617
Altitude Meters	3.1.4.15	12621
Rendesvous Radar	3.1.4.16	12621
IMU/CDU Control Requirements	3.1.5	N/A
CDU Zero	3.1.5.1	12617/12623
Coarse Align	3.1.5.2	12617/12623
Fine Align	3.1.5.3	12617/12619/12623
FDAI Linearity	3.1.5.4	12623
Total Attitude (GASTA) Interface	3.1.5.5	12623
IMU Cage	3.1.5.6	12616
RR/CDU Control Requirements	3.1.6	N/A
RR CDU Zero	3.1.6.1	12626
RR Designate Mode	3.1.6.2	12626
Velocity Meters	3.1.6.3	12623
Accelerometer Loops	3.1.7	N/A
PIPA Scale Factor	3.1.7.1	12624
PIPA Bias	3.1.7.2	12624
Stabilization Loops	3.1.8	N/A
Step Response	3.1.8.1	12619
Gimbal Torque Level	3.1.8.2	12619
IRIG Drift Coefficients	3.1.9	N/A
NBD	3.1.9.1	12624
ADIA	3.1.9.2	12624
ADSRA	3.1.9.3	12624
IRIG Scale Factor	3.1.10	12627
Abort Guidance System	3.1.12	N/A
Gimbal Angle Transmission Accuracy	3.1.12.1	12619/12623
Signal Conditioner Functional Checkout	3.1.13	12623
Prime Power	4.2.1.4.1	12618
Coolant Requirements	4.2.1.4.3	12611
Rotary Table Alignment Requirements	4.2.1.11	16010/16011/16012
Test Setup	4.2.1.12	sec par 4.2.1.12

4.2 GENERAL. The contractor responsible for system assembly shall be responsible for the accomplishment of each test required.

4.2.1 Test Conditions

4.2.1.1 Environmental. Unless otherwise specified, the system shall be tested under the following ambient conditions:

a. Temperature: 75° ±10°F
b. Relative Humidity: 90 percent max
c. Barometric Pressure: Ambient

5. PREPARATION FOR DELIVERY

5.1 GENERAL. With the exception of the IMU, preparation for delivery shall be in accordance with Specification ND1002214.

5.2 IMU Preparation for Shipment. The Inertial Measurement Unit shall be prepared for shipment in accordance with JDC17998, Packaging and Packing of IMU for Shipment.

6. NOTES. (To be supplied)

6.1 DEFINITIONS AND ABBREVIATIONS

APOLLO G&N Specification
PS6015000 REV
Original Issue Date:
Release Authority: TDRR 2534
Class A Release
CODE IDENT NO. 80230

MASTER END ITEM DETAIL SPECIFICATION

PART II

PRODUCT CONFIGURATION AND ACCEPTANCE TEST REQUIREMENTS

PGNCS SPACECRAFT EQUIPMENT

LEM

DRAWING NO. 6015000

MEI NO. 6015000

Record of Revisions

Date	Revision Letter	TDRR No.	Pages Revised	Approvals	
				MIT	NASA

This specification consists of page 1 to 33 inclusive.

APPROVALS	NASA/MSC	MIT/IL	ACSP
	18 Jan 1966		

3. REQUIREMENTS

3.1 PERFORMANCE

3.1.1 Standby Control

3.1.1.1 LEM Standby Mode. The following requirements shall be met with the IMU in the standby condition.

3.1.1.1.1 28 VDC IMU Standby. The IMU Standby voltage shall be 22.5±0.5 vdc.

3.1.1.1.2 Inertial Component Temperature. The PIPA temperature shall be 130±1.5°F. The IRIG temperature shall stabilize to within 1.0°F of the PIPA temperature within 1 hour after entering the Standby Mode.

3.1.1.2 G&N Standby Mode (LGC STBY). The following requirements shall be met with the IMU in the standby condition and the LGC in the standby condition.

3.1.1.2.1 28 VDC IMU Standby. The IMU Standby voltage shall be 28.0±0.5 vdc.

3.1.1.2.2 3200 cps Suspension Power. The 3200 cps suspension voltage shall be 28.0±0.56 volts rms at a frequency of 3200±1 cps.

3.1.1.2.3 Master Clock Sync. The Master Clock Sync signal characteristics shall be as follows. (See Figure 1).

a. Amplitude: 4.0 volts minimum.
b. Pulse Width: 0.50±0.25 microseconds.
c. Rise Time: 0.2 microseconds max. from 10 to 90 percent of amplitude.
d. Frequency: 1024K pps ±2 ppm over a 15 minute period.

3.1.1.3 G&N Standby Mode (LGC Operate). The following requirements shall be met with the IMU in the standby condition, the LGC in the operate condition, and the LGC +4 and +14 volt dc power supplies at 4.0±0.15 and 14.0±0.2, respectively.

3.1.1.3.1 Inhibit Power Fail. A LGC Warning discrete caused by a Voltage Fail alarm shall not occur with the Inhibit Power Fail discrete present at the LGC.

3.1.1.3.2 Low Voltage.

3.1.1.3.2.1 Voltage Fail Alarm. A Voltage Fail alarm shall occur, as indicated by the presence of a LGC Warning discrete, when the power supply outputs are independently decreased as follows:

a. One power supply output decreased from nominal to 3.6±0.05 vac.
b. The other power supply output decreased from nominal to 12.6±0.2 vdc.

3.1.1.3.2.2 LGC Fail Indication. Any of the LGC Fail indications may be present when the Inhibit Power Fail discrete is present and the power supply outputs are independently decreased as follows:

a. The power supply output at 3.6 vdc decreased to a maximum low of 2.5 vdc.
b. The power supply output at 12.6 vdc decreased to a maximum low of 8.0 vdc.

3.1.1.3.3 High Voltage

3.1.1.3.3.1 Voltage Fail Alarm. A Voltage Fail alarm shall occur, as indicated by the presence of a LGC Warning discrete, when the power supply outputs are independently increased as follows:

a. One power supply output increased from nominal to 4.5±0.2 vdc.
b. The other power supply output increased from nominal to 16.2±0.2 vdc.

3.1.1.3.3.2 LGC Fail Indication. Any of the LGC Fail indications may be present when the Inhibit Power Fail discrete is present and the power supply outputs are independently increased as follows:

a. The power supply output at 4.5 vdc increased to a maximum high of 5.2 vdc.
b. The power supply output at 16.2 vdc increased to a maximum high of 16.5 vdc.

3.1.2 Operate Control

3.1.2.1 IMU Operate Delay Indication. LGC Channel 30 shall indicate a "0" in bit 14 when the system is supplied with the +28 ±0.5 VDC IMU Operate power and shall remain in the "0" state for 90±5 seconds, after which time bit 14 of Channel 30 and bit 15 of Channel 12 shall indicate a "1".

3.1.2.1.1 Inertial Component Pulse Torquing. During the 90 second delay period, the IRIG and PIPA pulse torque power supply shall be inhibited. Loss of +28 VDC LGC prime power shall result in the same condition.

3.1.2.1.2 Automatic Caging and CDU Ambiguity Operation. The IMU gimbal resolvers shall drive until the 1X sine signals indicate 0.00±0.50 volts rms and the 1X cosine signals indicate 26.0±2.6 volts rms, with the IMU gimbal angles initially at 225°.

3.1.2.2 Inertial Component Temperature. The following requirements shall be met in the Operate mode with IMU gimbal angles of 0° ±5°.

3.1.2.2.1 Standby to Operate Transient. The PIPA temperature, 15 minutes after switching from the Standby mode to the Operate mode, shall be within 2.0°F of the temperature specified in 3.1.1.1.2.

3.1.2.2.2 Inertial Temperature Control Point. The IRIG and PIPA temperature, 15 minutes after switching from the Standby to Operate mode, shall be 136° ±1°F and 130.0±1.0°F, respectively. The IRIG and PIPA temperature shall remain stable to within ±0.2°F for a period of one hour thereafter.

3.1.2.2.3 Heater Telemetry Discrete. The Heater Telemetry Discrete shall cycle ON and OFF. The ON state shall be 28 ± 1 vdc at the interface.

3.1.2.2.4 Blower Telemetry Discrete. The Blower Telemetry Discrete shall remain in the ON state and shall be 28 ± 1.4 at the interface.

3.1.2.1.4 Phase Operation. The phase operation shall be indicated by 0 ±2 vrms at the [illegible] when the [illegible] is pulsed at the duty cycle of 5 percent to 95 percent [illegible]

3.1.2.3 800 CPS Power Supply Temperature. The indicated 800 cps power supply temperature shall be 70° ±40°F.

3.1.2.4 Temperature Monitor 1. The indicated temperature [illegible] 75° ±45°F.

3.1.2.5 Calibration Module Temperature. The indicated calibration module temperature shall be 87.8° ±27.8°F.

3.1.2.6 +28 VDC IMU Operate. The IMU Operate voltage shall be 28.5 +0, -1 vdc.

3.1.3 System Power Supplies. The system power supplies shall meet the following requirements.

3.1.3.1 IMU 28V, 1 Percent, 800 CPS Supply

3.1.3.1.1 Voltage. The output voltage shall be 28.0±0.56V rms with the guidance reference synchronizing pulse present.

3.1.3.1.2 Frequency. The output frequency shall be 800±1 cps with the guidance reference synchronizing pulse present.

3.1.3.2 IMU 28V, 5 Percent 800 CPS Supplies (Phases A and B)

3.1.3.2.1 Voltage. The output voltage of phase A shall be 28.0±1.4V rms and the output voltage of phase B shall be 28.0±2V rms.

3.1.3.2.2 Frequency. The frequency of the power supply outputs shall be 800±1 cps.

3.1.3.2.3 Phase. The output of the phase A supply shall be -90° ±10° with respect to the IMU 28V, 1 percent power supply output. The output of the phase B supply shall be -90° ±10° with respect to the IMU 28V, 5 percent, phase A power supply output.

3.1.3.3 ECDU +4 VDC Supply. The ECDU +4 vdc supply output voltage shall be +4.0±0.2 vdc.

3.1.3.4 Minus 28 VDC Supply. The -28 vdc supply output voltage shall be -27.5±6.0 vdc.

3.1.3.4 Minus 28 VDC Supply

3.1.3.4.1 Voltage. The output voltage shall be -27.5±6.0 vdc.

3.1.3.5 Pulse Torque Power Supply. The pulse torque power supply outputs shall be as follows at the interface.

	OUTPUT	VOLTAGE
a.	120 vdc (1)	120±6 vdc
b.	28 vdc (PVR) (3)	28.0±1.4 vdc

3.1.3.6 800 CPS Reference Voltage. The reference voltage at the interface shall have the following characteristics.

3.1.3.6.1 Amplitude. The amplitude shall be 28.00V rms ±2 percent.

3.1.3.6.2 Frequency. The frequency shall be 800±1 cps.

3.1.3.7 3200 CPS Suspension Power. The 3200 cps suspension power supply shall have the following characteristics with the LGC in Standby or Operate, [illegible].

3.1.3.7.1 Voltage. The Feedback voltage of the 3200 cps supply shall be 28.00±0.56V rms.

3.1.3.7.2 Frequency. The frequency shall be 3200±1 cps.

3.1.3.7.3 Phase. The phase angle of the 3200 cps supply shall be at 0° ±10° with respect to the 3200 pps synchronizing pulse train.

3.1.3.8 LGC +4 VDC Power Supply. The output voltage of the LGC +4 vdc power supply shall be +4.00±0.15 vdc.

3.1.3.8.1 Noise. The peak-to-peak noise level shall be 0.4 volt or less.

3.1.3.8.2 ACE Bias 1. The +4 vdc power supply output shall drop by 0.30 ±0.1 vdc with the requirement of paragraph 4.2.1.4.2.6 met.

3.1.3.9 LGC +14 VDC Power Supply. The output voltage of the LGC +14 vdc power supply shall be +14.00±0.20 vdc.

3.1.3.9.1 Noise. The peak-to-peak noise level shall be 0.4 volt or less.

3.1.3.9.2 ACE Bias 2. The +14 vdc power supply output shall drop by 0.90±0.1 vdc with the requirement of paragraph 4.2.1.4.2.6 met.

3.1.3.10 LGC +28 VDC. The +28 vdc COMP TP voltage shall be +28.0 +4.8, -3.5 vdc, -0.5 vdc.

3.1.4 LEM Guidance Computer (LGC)

3.1.4.1 Operational Self-Check. The LGC program shall: sum fixed memory; verify the execution of the machine instructions, control pulses, interupts, and timing; and exercise the erasable, central, and special registers. In addition, the program shall verify the proper operation of all electro-luminescent displays on the DSKY.

3.1.4.2 Keyboard Operation. Actuation of each listed pushbutton shall result in a displayed indication as follows:

a. Verb: (preceding and in conjunction with two numeral pushbuttons) shall result in the illumination of the same numerals in the VERB display window.

b. Noun: (preceding and in conjunction with two numeral pushbuttons) shall result in the illumination of the same numerals in the NOUN display window.

c. 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, +, -; shall result in illumination of the respective characters on the DSKY display.

d. CLR: shall result in deletion of illuminated characters on R-1, R-2, and R-3 during a data load sequence on the DSKY display, provided the ENTER pushbutton has not been pressed during the entry sequence.

e. STBY: shall extinguish all DSKY illumination except that of the STBY and TEMP lamps after preparing the LGC for STBY.

f. CAUT RSET: shall extinguish any or all of the following DSKY display lamps when illuminated.

(1) PROG
(2) RESTART
(3) OPR ERR

g. KEY REL: shall extinguish the KEY REL DSKY display lamp and return the DSKY control to the monitoring routine which is commanded by the LGC.

h. ENTER: shall result in the completion of a legal entry depending upon the actuation of the proper sequence of VERB, or VERB, NOUN, plus numeral pushbuttons.

3.1.4.3 Display Operation. Each listed display lamp shall illuminate as a result of specified stimuli.

a. All listed lamps (b through m) shall be capable of lamp element operation verification through the use of VERB 35.

b. STBY: shall illuminate after actuation of the STBY pushbutton for at least 2 seconds after preparing the LGC for STBY.

c. KEY REL: shall illuminate by presence of a "1" in bit 5 of CH 11.

d. GIMBAL LOCK: shall illuminate by presence of a "1" in bit 6 of RLYWD 1100 with the MIDDLE gimbal CDU indicating angles between 07000 and 29000 as demonstrated by interrogation of the CDU counter address (00052) in the LGC.

e. TEMP: shall illuminate by presence of a "1" in bit 4 of CH 11.

f. PROG: shall illuminate by presence of a "1" in bit 9 of RLYWD 1100 subsequent to an illegal program function or PIPA FAIL.

g. RESTART: shall only illuminate as a result of any or all of the following conditions:

(1) STANDBY
(2) TC TRAP
(3) RUPT LOCK
(4) PARITY FAIL
(5) NIGHT WATCHMAN
(6) VOLTAGE FAIL

h. TRACKER: shall illuminate by presence of a "1" in bit 8 of RLYWD 1100.

i. OPR ERR: shall illuminate by presence of a "1" in bit 7 of CH 11.

j. COMP ACTY: shall illuminate by presence of a "1" in bit 2 of CH 11.

k. UPLINK ACTY: shall illuminate by presence of a "1" in bit 3 of CH 11.

m. Electro-luminescent Elements: The following numeric displays shall illuminate by program as DSKY circuit or both.

(1) PROG
(2) VERB
(3) NOUN
(4) REGISTER 1
(5) REGISTER 2
(6) REGISTER 3

3.1.4.4 LGC Commands to Reaction Control System (RCS). With a "1" in the following bit assignments, a voltage of less than 5 vdc shall be present at the interface. With a "0" in the following bit assignments, a voltage of 10±1 vdc shall be present at the interface.

Channel 5	Bit No.
+X RCS Jet 4D	2
+X RCS Jet 3D	4
+X RCS Jet 2D	6
+X RCS Jet 1D	8
-X RCS Jet 4U	1
-X RCS Jet 3U	3
-X RCS Jet 2U	5
-X RCS Jet 1U	7

Channel 6	Bit No.
+Y RCS Jet 2S	5
+Y RCS Jet 1S	8
-Y RCS Jet 4S	7
-Y RCS Jet 3S	6
+Z RCS Jet 3F	1
+Z RCS Jet 2F	4
-Z RCS Jet 4F	2
-Z RCS Jet 1F	3

3.1.4.5 LGC Commands to Main Engine. The interface shall exhibit the following pulse characteristics upon command from the LGC.

a. Increase Throttle Rate Descent Engine.
b. Decrease Throttle Rate Descent Engine.

3.1.4.5.1 Pulse Characteristics (See Figure 1)

a. Amplitude (A): 7±3V
b. Width at A/2 Point: 3±1 μsec
c. Droop: 20 percent at 2 μsec from A peak
d. Backswing: 4 volts peak with respect to the amplitude reference level
e. Risetime: 0.2 μsec max (10 percent to 90 percent of A)
f. Repetition Rate: 3.2K pps
g. Max Noise: +0.4 to -4.0 volts with respect to the amplitude reference level.

3.1.4.6 LGC Commands to Stabilization Control System. The following interface shall exhibit 5 vdc or less for a logic 1, or 10±1 vdc for a logic 0, command to the specified bit assignments of LGC CH 11 and CH 12.

Interface	Bit	Channel
Engine On Asc or Desc	13	11
Engine Off Asc or Desc	14	11
+Pitch Gimbal Trim	9	12
-Pitch Gimbal Trim	10	12
+Roll Gimbal Trim	11	12
-Roll Gimbal Trim	12	12

3.1.4.6.1 Noise Requirements

a. Switch Closed ("1"): The maximum noise amplitude shall not exceed -50V and pulse width shall not exceed 0.5 msec at a maximum repetition rate of 50 pps.

b. Switch Open ("0"): The maximum noise amplitude shall not exceed +5V and pulse width shall not exceed 1.0 msec at a maximum repetition rate of 50 pps.

3.1.4.7 LGC Discrete Inputs. Each interface specified below, when excited in accordance with the appropriate voltage specified in paragraph 4.2.1.4.2, shall cause the proper bit states, as specified in Table I.

TABLE I

LGC DISCRETE INPUTS

DISCRETE	CHANNEL	BIT	ON BIT STATE	OFF BIT STATE
Abort	30	1	0	1
Abort Stage	30	4	0	1
Engine Armed	30	3	0	1
Display Inertial Data	30	6	0	1
Att Hold Mode	32	11	0	1
Stage Verify	30	2	0	1
Auto Throttle	31	13	0	1
Auto Stabilization	31	14	0	1
Thruster pr 4D/4S Fail	32	1	0	1
Thruster pr 3U/3S Fail	32	2	0	1
Thruster pr 4U/4F Fail	32	3	0	1
Thruster pr 3D/3F Fail	32	4	0	1
Thruster pr 1D/1S Fail	32	5	0	1
Thruster pr 1U/1F Fail	32	6	0	1
Thruster pr 2U/2S Fail	32	7	0	1
Thruster pr 2D/2F Fail	32	8	0	1
G&N Control of S/C	31	15/16	0	1
+EL (LPD)	31	1	0	1
-EL (LPD)	31	2	0	1
+AZ (LPD)	31	5	0	1
-AZ (LPD)	31	6	0	1
+X Trans Comm (Man)	31	7	0	1
-X Trans Comm (Man)	31	8	0	1
+Y Trans Comm (Man)	31	9	0	1
-Y Trans Comm (Man)	31	10	0	1
+Z Trans Comm (Man)	31	11	0	1
-Z Trans Comm (Man)	31	12	0	1
Rate of Descent (+)	16	6	1	0
Rate of Descent (-)	16	7	1	0
Rate of Descent Reset	16	6 or 7	0	1
IMU Cage Command	30	11	0	1
Pitch Gimbal Off	32	9	0	1
Roll Gimbal Off	32	10	0	1
LR Range Data Good	33	5	0	1
LR Position 1 (Desc)	33	6	0	1
LR Position 2 (Hover)	33	7	0	1
LR Vel Data Good	33	8	0	1
LR Range Lo Scale	33	9	0	1
RR Range Lo Scale	33	3	0	1
RR Power On/Auto	33	2	0	1
RR Data Good	33	4	0	1

3.1.4.7.1 Mark X. Actuation of the MARK X pushbutton shall cause a "1" to be present in bit 3 of CH 16.

3.1.4.7.2 Mark Y. Actuation of the MARK Y pushbutton shall cause a "1" to be present in bit 4 of CH 16.

3.1.4.7.3 Mark Reject. Actuation of the MARK REJECT pushbutton shall cause a "1" to be present in bit 5 of CH 16.

3.1.4.8 Landing Radar (LR) Requirements. The LR Read Cycle shall be commanded by LGC program. The Read Cycle shall consist of a constant 3200 cycle pulse train output (LR Gate Reset Strobe) in conjunction with one of four 3200 Gate Strobes (X_{A_1} Y_{A_1} Z_A or Range). Subsequent to issuance of the Gate Strobe, a Read Out Sync burst shall be commanded. Each Gate Strobe shall be commanded in conjunction with the Reset Strobe and Read Out Sync burst and shall appear at the interface.

3.1.4.8.1 Pulse Characteristics and Data Acquisition. With the conditions as specified in 3.1.4.8, and with the LR Range Data Good discrete present at the LGC interface when using the LR Range Gate Strobe; or with the LR Velocity Data Good discrete present at the LGC interface when using either Velocity Gate Strobe; the following pulse and data acquisition characteristics of the interface specified in 3.1.4.8 shall be as follows. (See Figure 1 for wave shape description.)

a. Amplitude (A): 7±3V peak-to-peak

b. Pulse Width at A/2 Point: 3.0±0.5 microseconds

c. Droop: 20 percent of A at 2 microseconds

d. Maximum Backswing: 4 volts peak

e. Risetime: 0.2 microseconds from 10 to 90 percent of A

f. Frequency: 3.2K pps

g. Noise: No pulse <+0.4 volts peak

h. Gate Strobe Timing: LR Radar Gate Reset Strobe pulse shall lead either LR Range or Velocity Gate Strobe pulse by 2.0±0.25 microseconds as determined at the respective A/2 points.

i. Read Cycle Timing: The elapsed time between issuance of the first Gate Strobe pulse and the first Read Out Sync pulse shall be not less than 80.315 milliseconds.

3.1.4.8.2 Data Acquisition Characteristics. A known sequence of LR "0"s and LR "1"s shall result in duplication of the specified sequence in counter 46 of LGC.

3.1.4.8.3 LR Antenna Position Command: With a "1" in bit 13 of CH 12, the interface shall exhibit less than 5 vdc. With a "0" in bit 13 of CH 12, the interface shall exhibit 10±1 vdc.

3.1.4.9 Attitude Hand Controller. With the Attitude Control Out of Detent discrete present in the LGC, a scale factor of 0.254V rms per bit and linearity of 10 percent shall be exhibited as follows:

Hand Controller Command

a. Prop. Pitch Rate Cmd.
b. Prop. Roll Rate Cmd.
c. Prop. Yaw Rate Cmd.

3.1.4.9.1 Attitude Control Out of Detent. With the Attitude Control Out of Detent discrete present, a "0" shall be present in bit 3 of CH 31.

3.1.4.10 Telemetry Uplink (UPLINK "0", UPLINK "1"). An Accept Uplink discrete of a "1" in Channel 13, bit 5, in accordance with 4.2.1.4.2 shall enable the acceptance of Uplink Data.

3.1.4.10.1 Transmission Verification. Interrogation of the LGC erasable memory shall determine if a known sequence of "0"s and "1"s applied, at the interface is accepted by the LGC.

3.1.4.10.2 Telemetry Verification. With a pulse train of all "0"s and all "1"s applied to the interface as specified in 3.1.4.10.1, the amplitude of the "0"s pulses shall be 0.0±0.4V relative to a "0" level of 7±3V peak to peak, and the amplitude of the "1"s pulses shall be 7±3V peak to peak.

3.1.4.11 Telemetry Downlink. With the Dink Start, Dink End and Dink Sync signals in accordance with the requirements of 4.2.1.4.2, and with Dink Start and End pulses occurring at 10, 50 or 200 pps, a 40-bit word shall be present at a word or burst frequency of 10, 50 or 200 per second.

3.1.4.11.1 Downlink Data. The "1" pulse shall have the following characteristics:

a. Amplitude (A): 7±2V pp
b. Width at A/2: 2 to 6 μsec
c. Maximum Droop at 2.0 μsec following the leading edge: 20 percent of A
d. Maximum risetime at 10 to 90 percent of A: 0.2 μsec
e. Maximum delay with respect to the bit sync pulse: 1.0 μsec
f. Noise (Zero Pulse): +0.4V max, -6V max

3.1.4.12 LGC Warning. The LGC Warning discrete shall occur as a result of any or all of the following conditions.

a. RESTART
b. COUNTER FAIL
c. VOLTAGE FAIL (in standby mode)
d. LIGHT TEST
e. Scalar double alarm
f. SCAFAL
g. LGC +28 VDC FAIL

3.1.4.13 ISS Warning. The ISS Warning discrete shall occur as a result of a "1" in bit 1 of CH 11.

3.1.4.14 PGNS Caution. The PGNS Caution discrete shall occur as a result of any or all of the following conditions:

a. Program Caution: a "1" in bit 9 of RLYWD 1100
b. Temperature: a "1" in bit 4 of CH 11
c. Gimbal Lock: a "1" in bit 6 of RLYWD 1100
d. Tracker: a "1" in bit 8 of RLYWD 1100
e. RESTART

3.1.4.15 Altitude Meters. The LGC shall command known data words, Altitude "0", Altitude "1", Altitude Rate "0", and Altitude Rate "1". The pulse characteristics of the data words shall be as follows:

a. Amplitude (A): 7±3V
b. Pulse Width at A/2 Point: 3±1 microsec
c. Droop: 20 percent of A at 2 microsec
d. Maximum Backswing: 4V
e. Risetime: 0.2 microsec max from 10 percent to 90 percent of A
f. Frequency: 3.2K pps±1 pps.

3.1.4.16 Rendezvous Radar (RR). The RR Read Cycle shall be commanded by LGC program. The Read Cycle shall consist of a constant 3200 cycle pulse train output (RR Gate Reset Strobe) in conjunction with one of two Gate Strobe (Range or Range Rate) outputs. Subsequent to issuance of the Gate Strobe, the Read Out Sync burst shall be commanded. Each Gate Strobe shall be commanded in conjunction with the Reset Strobe and Read Out Sync burst and shall appear at the interface.

3.1.4.16.1 Pulse Characteristics and Data Acquisition. Under the conditions of 3.1.4.16, and with the RR Data Good discrete present at the LGC interface as demonstrated by a "1" in bit 4 of CH 33, the following pulse and data acquisition characteristics shall exist.

3.1.4.16.1.1 Pulse Characteristics. The pulse characteristics of the pulse signals specified in 3.1.4.16 shall be as follows. (See Figure 1 for the wave shape requirements.)

a. Amplitude (A): 7±3V

b. Pulse Width at A/2: 3±0.5 microseconds

c. Droop: 20 percent of A at 2 microseconds

d. Maximum Backswing: 4V peak

e. Risetime: 0.2 microseconds from10 to 90 percent of A

f. Frequency: 3.2K pps ±1 pps

g. Noise: No pulse < +0.4V peak

h. Gate Strobe Timing: The Radar Gate Reset Strobe pulse shall lead either RR Gate Strobe pulse by 2.0±0.25 microseconds at the respective A/2 points.

i. Read Cycle Timing: The elapsed time between issuance of the first Gate Strobe pulse and the first Read Out Sync pulse shall be not less than 80.935 milliseconds.

3.1.4.16.1.2 Data Acquisition Characteristics. A known sequence of RR "0"s and RR "1"s shall result in duplication of that sequence in counter 46 in LGC.

3.1.5 IMU/CDU Control Requirements

3.1.5.1 CDU Zero. The following requirement shall be met when the CDU s are commanded to ZERO.

3.1.5.1.1 Mode Initiation. This mode shall be initiated by entering Verb 40, Noun 20, at the LGC DSKY.

3.1.5.1.2 AGS CDU Zero Indication. The AGS CDU zero indication shall be present for a minimum of 300 milliseconds and shall exhibit the following pulse characteristics.

a. Amplitude (1 state): 7±3V
b. Maximum Amplitude (0 state): +0.4 to -4V peak
c. Maximum Risetime at 10 to 90 percent of A: 0.5 microsecond
d. Pulse Width at A/2: 3.0±1.0 microseconds
e. Maximum Droop at 2 microseconds after leading edge: 20 percent of A
f. Frequency: 51.2K pps ±10 percent

3.1.5.2 Coarse Align. The mode shall be initiated by entering Verb 41, Noun 20 at the LGC DSKY.

3.1.5.2.1 Command Accuracy. The LGC shall command the IMU gimbals to 45, 135, -45 and -135 degree angles with an accuracy of ±1.5 degrees.

3.1.5.2.1 Add

3.1.5.2.2 AC D/A Command. The AC D/A output at the interface shall not exceed 0.30V rms subsequent to completion of torquing command.

a. IG AC D/A Error
b. MG AC D/A Error
c. OG AC D/A Error

3.1.5.2.3 Torquing Rate. The CDU, when stimulated by the maximum LGC torquing command, shall exhibit an average gimbal torquing rate of 1±2 degrees per second over a range of 67.5 degrees.

3.1.5.3 Fine Align. The mode shall be initiated by entering Verb 42 at the LGC DSKY.

3.1.5.3.1 CDU Lead Repeatability Accuracy. The LGC shall be capable of repeating given IG and OG angles in each quadrant to within 0±0.01 degrees. The same repeating accuracy shall be met for MG angles of less than ±70.0 degrees.

3.1.5.3.1.1 CDU Read Ambiguity. The IG and OG CDU's shall be capable of repeating an angle of 225 (–135) ±2 degrees.

3.1.5.3.2 CDU Repeating Rate. The IMU CDU's shall exhibit a repeating rate of not less than 70 degrees per second for error angles in excess of 792 arc seconds. The repeating rate shall be 4.5±0.5 degrees per second for error angles less than 793 arc seconds.

3.1.5.3.3 CDU Fine Error. The dynamic error at the interface shall not exceed 0.070 volts rms through out a range of 22.5 degrees of IMU gimbal rotation.

a. IG Fine Error
b. MG Fine Error
c. OG Fine Error

3.1.5.3.4 CDU Coarse Error. The dynamic error at the interface shall not exceed 0.680 volts rms through an inner and outer IMU gimbal rotation of 360° degrees.

a. IG Coarse Error
b. MG Coarse Error
c. OG Coarse Error

3.1.5.3.5 IMU CDU Fail. CDU Fail indicated by a "0" in bit 12 of CH30 shall occur with a difference of 1.0±0.1 degree (fine error) or 33.75±0.3 degree (coarse error) between the CDU read counter and the IMU gimbal resolvers.

3.1.5.4 FDAI Linearity. The LGC shall command the following angular increments to each CDU resulting in the voltage and phase outputs as specified at the interface.

Increment (deg)	CDU A/C DAC Error (volts)	(Phase wrt ref.)
+17	+5.05±10%	in
+16	+4.86±10%	in
+6	+1.8±10%	less than 8° shift
0	0.056 max	N/A
-6	-1.8±10%	Out
-16	-4.86±10%	Out
-17	-5.05±10%	Out

3.1.5.5 Total Attitude (GASTA) Interface. With the IMU gimbal angles at 45.0 degrees, the output at the interface shall be 18.4±1.84V.

a. Cos AIG 1X
b. Sin AIG 1X
c. Cos AMG 1X
d. Sin AMG 1X
e. Cos AOG 1X
f. Sin AOG 1X

3.1.5.5.1 Phase Shift. The phase of the cosine output shall be within 0.5 degree of the sin output. The phase of the sin output shall not exceed 6.0±5.0 degrees with respect to the reference.

3.1.5.5.2 Null Voltage. With the IMU gimbal angles commanded to 0.0° ±0.01 degrees for the sine output and 90.0° ±0.01 degrees for the cosine output, the total null voltage shall not exceed 100 mv rms and the inphase null shall not exceed 3.0 mv rms.

3.1.5.5.3 Phasing. The sine and cosine outputs shall be in phase (0°) with the reference for gimbal angles of +45.0 degrees and shall be out of phase (180°) for gimbal angles of +215.0 degrees.

3.1.5.6 IMU Cage. The IMU gimbals shall drive until the resolver 1X sine signals indicate 0.0±0.5 volts rms with the IMU gimbals initially coarse aligned to 10 degrees and with the IMU Cage discrete present at the interface. Upon removal of the IMU Cage discrete from the interface, the Stable Member shall become inertial.

3.1.6 RR/CDU Control Requirements

3.1.6.1 RR CDU Zero. This mode shall be initiated by entering Verb 40, Noun 55 at the LGC DSKY.

3.1.6.1.1 LGC Counters. The RR Shaft and Trunnion Counters at locations 00054 and 00053 in the LGC shall indicate all zeros.

3.1.6.2 RR Designate Mode. This mode shall be initiated by entering Verb 41, Noun 55 at the LGC DSKY.

3.1.6.2.1 Angular Command Accuracy. The LGC shall command +9, +6, 0, -6, -9 degree increments to the shaft and trunnion CDU DAC's. The voltage output of the RR Shaft AC D/A Error and RR Trunnion AC D/A Error shall be +4.5±0.27, +3±0.18, less than 0.056, -3.0±0.18, and -4.5 ±0.27 volts rms respectively, the minus sign indicating that the output is out of phase with respect to the reference.

3.1.6.2.2 Angular Tracking Accuracy. With the RR Data good and the Auto Angle Track Enable discrete present and with a simulated Shaft and Trunnion gimbal angle of 45.00 degrees, the Shaft and Trunnion counters in the LGC shall indicate the gimbal angles within ±0.02 degrees.

3.1.6.2.2.1 Shaft and Trunnion 1X Resolver Interface. The Shaft and Trunnion 1X sine and cosine outputs shall be 19.65±0.98 volts rms at a 1X angle of 45.000 degrees.

3.1.6.2.2.2 Shaft and Trunnion 16X Resolver Interface. The Shaft and Trunnion 16X sine and cosine outputs shall be 3.53±0.18 volts rms at a 1X angle of 2.812 degrees.

3.1.6.2.2.3 RR CDU Fine Error. The steady state voltage of the RR Shaft Fine Error and RR Trunnion Fine Error outputs shall not exceed 0.070 volts rms.

3.1.6.2.2.4 RR CDU Coarse Error. The steady state voltage of the RR Shaft Coarse Error and RR Trunnion Coarse Error outputs shall not exceed 0.680 volts rms.

3.1.6.2.2.5 RR CDU Fail. CDU Fail indicated by a "0" in bit 7 of Channel 30 shall occur with a difference of 1.0±0.1 degree (fine error) or 33.75±0.3 degrees (coarse error) between the CDU read counter and the RR gimbal resolvers.

3.1.6.2.2.6 RR Auto-Angle Track Enable Command. A "1" in bit 14 of Channel 12 shall result in a voltage of less than 5 vdc. A "0" in bit 14 of Channel 12 shallresult in a voltage of 10±1 vdc.

3.1.6.3 Velocity Meters. When the Display Inertial Data discrete is present, the Lateral and Forward velocity outputs shall be as specified when the following rates are commanded by the LGC.

Rate (fps)	CDU DC DAC Output (vdc)
0	±0.007 *
+0.56	+0.014 ±10%
+1.11	+0.028 ±10%
+2.23	+0.056 ±10%
+4.46	+0.113 ±6%
+8.91	+0.226 ±6%
+17.82	+0.452 ±6%
+35.65	+0.904 ±6%
+71.31	+1.808 ±6%
+89.13	+2.258 ±3%
+142.62	+3.616 ±6%
+200.0	+5.074 ±6%
+199.48	+5.060 ±6%
-89.13	-2.258 ±3%
-200.0	-5.074 ±6%

* Noise: At DC null; less than 5.0 mv rms at frequencies below 25 cps, 30 mv rms at frequencies above 25 cps.

3.1.7 Accelerometer Loops

3.1.7.1 PIPA Scale Factor. The PIPA scale factor in a 1g field shall be ____±____ cm/sec/pulse.

3.1.7.2 PIPA Bias. The PIPA bias in a 1g field shall not exceed _____cm/sec^2.

3.1.8 Stabilization Loops.

3.1.8.1 Step Response. The IRIG floats shall be initially displaced from electrical null by application of 10, 5 and 5 vdc ±5% to the test inputs of the respective Inner, Middle and Outer gimbal DC Amplifiers and shall return to null upon removal of this voltage. The time interval between the removal of this disturbance and the peak magnitude of the first overshoot shall not exceed 0.2 seconds. In addition, the number of over shoots shall not exceed 2.

3.1.8.2 Gimbal Torque Level. The friction level of each gimbal, when torqued by its IRIG shall not exceed 26.2 in-oz, indicated by a peak torque motor current not exceeding 0.125 amps.

3.1.9 IRIG Drift Coefficients

3.1.9.1 NBD. The IRIG bias drift (NBD) shall not deviate more than _____ meru from the associated REFERENCE VALUE as established from the performance of ATP6015497.

3.1.9.2 ADIA. The IRIG drift due to acceleration along the input axis (ADIA) shall not deviate more than _____ meru/g from the associated REFERENCE VALUE as established from the performance of ATP6015497.

3.1.9.3 ADSRA. The IRIG drift due to acceleration along the spin reference axis (ADSRA) shall not deviate more than _____meru/g from the associated REFERENCE VALUE as established from the performance of ATP6015497.

3.1.10 IRIG Scale Factor. The IRIG pulse torque scale factor shall be 2π radians/2^{21} pulses ±1750 PPM.

3.1.11 System Fine Alignment Accuracy. The stable member (SM) as defined by the X, Y and Z PIPA input axes shall be aligned to predetermined orientations with respect to the IMU mounting pads with a maximum error of 200 arc seconds about any PIPA input axis as accomplished by an LGC alignment.

3.1.12 Abort Guidance System

3.1.12.1 Gimbal Angle Transmission Accuracy. A plus and minus gimbal angle increment (ΔA) about each axis shall be commanded by the LGC. A total pulse count of $\Delta A(0.01098)\pm1$ pulse shall be present on the plus and minus $\Delta\theta$ abort signals.

3.1.12.1.1 Pulse characteristics of Δθ Abort Signals. With a constant rate of change of the Δθ Abort pulse commanded by the LGC, the pulse characteristics of the Δθ Abort signals shall be: shall be as follows. (See Figure 1)

a. Amplitude (A): 7±8 volts peak
b. Rise Time: 0.5 microseconds at 10% to 90% of A
c. Pulse Width: 3.0±1 microseconds at 50% of A
d. Droop: 20% of A max
e. No Pulse Amplitude: −4.0 volts min to +4 volts max with reference to the zero vdc reference.

3.1.12.2 Abort Guidance Downlink Data. The AGS Downlink Data shall be in accordance with paragraph 3.1.4.11.

3.1.[illegible] Telemetry Interface TBD (To be defined)

3.2. PRODUCT CONFIGURATION. The configuration of the assembly shall be in accordance with APOLLO G&N Drawing 6015000 and all drawings and engineering data referenced thereon.

3.2.1 Drawings. The configuration of the assembly shall be in accordance with APOLLO G&N Drawing 6015000 and all drawings and engineering data referenced thereon.

3.2.2 Maximum Weight.

4. QUALITY ASSURANCE PROVISIONS

4.1 PRODUCT PERFORMANCE AND CONFIGURATION REQUIREMENTS/QUALITY VERIFICATION CROSS REFERENCE INDEX

Test/Examination	Requirement	JDC Method
LEM G&N System Power Supplies Test	3.1.3	12618

4.2 GENERAL. The contractor responsible for system assembly shall be responsible for the accomplishment of each test required herein.

4.2.1 Test Conditions

4.2.1.1 Environmental. Unless otherwise specified, the system shall be tested under the following ambient conditions:

a. Temperature: 75° ±10°F
b. Relative Humidity: 90 percent max
c. Barometric Pressure: Ambient

4.2.1.2 Prior Compliance. Prior to system testing, assembly level and subsystem testing and inspection shall have been accomplished in accordance with ATP6015497 (ISS Subsystem), and PS2008101 (LGC Group) [illegible].

4.2.1.3 Output Loading. The output loading required during testing shall be as specified in Table II.

TABLE II

OUTPUT LOADING

	SIGNAL	LOAD (Ohms)
FDAI	IG AC D/A error	20K ±5%, 0° ±5°
	MG AC D/A error	20K ±5%, 0° ±5°
	OG AC D/A error	20K ±5%, 0° ±5°
	800 cps, 28V, 1% Ref.	To be defined
GASTA (TOTAL ATTITUDE)	Sin AIG 1X	415±15% +j1950±10%
	Cos AIG 1X	↕
	Sin AMG 1X	↕
	Cos AMG 1X	↕
	Sin AOG 1X	↕
	Cos AOG 1X	415±15% +j1950±10%
ABORT GUIDANCE SECTION	+1G Delta Theta Abort	500±10%
	−1G Delta Theta Abort	↕
	+MG Delta Theta Abort	↕
	−MG Delta Theta Abort	↕
	+OG Delta Theta Abort	↕
	−OG Delta Theta Abort	↕
	CDU Zero	↕
	AGS Initialization (DNLK Data)	500±10%

4.2.1.4.2 Signals. The system input signals shall be as specified in Table IV.

TABLE IV
SYSTEM INPUT SIGNALS

SIGNAL	EXCITATION CHARACTERISTICS
Abort Abort Stage Engine Armed Display Inertial Data Att Control Out of Det Att Hold Mode Stage Verify Auto Throttle Auto Stabilization Thruster pr 4D/4S Fail Thruster pr 3U/3S Fail Thruster pr 4U/4F Fail Thruster pr 3D/3F Fail Thruster pr 1D/1S Fail Thruster pr 1U/1F Fail Thruster pr 2U/2S Fail Thruster pr 2D/2F Fail G&N Control of S/C (Digital Auto Pilot in Control) +EL (LPD) -EL (LPD) +AZ (LPD) -AZ (LPD) +X Trans Comm (Man) -X Trans Comm (Man) +Y Trans Comm (Man) -Y Trans Comm (Man) +Z Trans Comm (Man) -Z Trans Comm (Man) Rate of Descent (+) Rate of Descent (-) Rate of Descent Reset IMU Cage Command Pitch Gimbal Off Roll Gimbal Off LR Range Data Good LR Position 1 (Desc) LR Position 2 (Hover) LR Vel Data Good LR Range Lo Scale RR Data Good RR Range Lo Scale RR PWR ON & in Auto LGC Mode	Switch ON: 17.5±0.5 vdc Switch OFF: 0±2 vdc
Prop Pitch Rate Cmd Prop Roll Rate Cmd Prop Yaw Rate Cmd	See 4.2.1.4.2.1

TABLE IV (Continued)

SIGNAL	EXCITATION CHARACTERISTICS
L Rdr In 0 L Rdr In 1 R Rdr In 0 R Rdr In 1	See 4.2.1.4.2.2
RR Shaft Sin 16X RR Shaft Cos 16X RR Trunnion Sin 16X RR Trunnion Cos 16X	See 4.2.1.4.2.3
RR Shaft Sin 1X RR Shaft Cos 1X RR Trunnion Sin 1X RR Trunnion Cos 1X	See 4.2.1.4.2.4
Dlnk Start Dlnk End Dlnk Sync	See 4.2.1.4.2.5.1
Uplnk "0" Uplnk "1"	See 4.2.1.4.2.5.2
ACE Bias 1 ACE Bias 2	See 4.2.1.4.2.6
Inhibit Power Fail	28.0±4.5 vdc
LR Antenna Pos #1 Auto Angle Track Enable RCS Jet 4D RCS Jet 3D RCS Jet 2D RCS Jet 1D RCS Jet 3U RCS Jet 2U RCS Jet 4U RCS Jet 1U RCS Jet 2S RCS Jet 1S RCS Jet 3S RCS Jet 2F RCS Jet 3F RCS Jet 4F RCS Jet 1F Engine On Asc or Desc Engine Off Asc or Desc + Pitch Trim - Pitch Trim + Roll Trim - Roll Trim	10±1 vdc through a resistive impedance of 2K ±10% ohms ↕ 10±1 vdc through a resistive impedance of 2K ±10% ohms

4.2.1.4.2.1 Attitude Hand Controller. The excitation shall provide the following signal characteristics:

a. Null Voltage: 30 mv rms max
b. Quadrature: 10 mv rms max
c. Voltage Range: 0 to 2.80±0.14V rms
d. Source Impedance: 2K ohms at 85°
e. Excitation: 28V, 800 cps, 5 percent, from the system
f. Maximum Phase Shift: 10°
g. An inphase output represents a positive rate command
h. Linearity: 5 percent

4.2.1.4.2.2 Radar Data Pulse Characteristics. The excitation shall provide the following signal characteristics:

a. Amplitude (A): 7±3V
b. Pulse Width at A/2 Point: 4±2 microsec
c. Droop: 20 percent max of A at 2 microsec
d. Maximum Backswing: 4V
e. Risetime: 0.20 microsec max from 10 percent to 90 percent of A
f. Repetition Rate: 3.2K pps
g. Timing: Read Out Sync pulse shall lead either data pulses by a maximum of 1 microsecond determined at the respective A/2 points.

4.2.1.4.2.3 RR 16X Resolver Sin and Cosine (Shaft and Trunnion)

a. Sense: Positive angle rotation – sine and cosine voltages shall be inphase with the reference voltage for the first 90 electrical degrees of resolver rotation.

b. Zero: Resolver electrical zero corresponds to shaft and trunnion zero angle position. The electrical zero occurs when the sine signal is at null and the cosine signal is at maximum and inphase with the reference excitation signal. The 16X resolver shall be the primary alignment reference index for both shaft and trunnion. The electrical reference zero of the 16X and 1X outputs of each resolver shall coincide within 5 arc minutes of the mechanical shaft angle.

c. Output Form

(1) Sin: $e_{16s} = E_3 \sqrt{2} \sin (16A) \sin (2\pi ft + \phi_3)$

(2) Cosine: $e_{16c} = E_4 \sqrt{2} \cos (16A) \sin (2\pi ft + \phi_4)$

Where:

$E_3 = E_4 = 5V$ rms ±5 percent (output voltage)
A = Antenna gimbal angle
f = Ref frequency (800 cps ±0.5 percent)
t = Time
ϕ_3 and ϕ_4 = phase shift (11° ±5° with respect to the ref voltage)

d. Nulls at any position: 10 mv rms in phase max

e. Maximum DC Source Impedance: 200 ohms – each winding

4.2.1.4.2.4 RR 1X Resolver Sine and Cosine (Shaft and Trunnion)

a. Sense: Positive angle rotation – sine and cosine voltages shall be inphase with the reference voltage for the first 90 electrical degrees of resolver rotation.

b. Zero: Resolver electrical zero corresponds to shaft and trunnion zero angle position. The electrical zero occurs when the sine signal goes to null and the cosine signal is near maximum and inphase with the reference excitation signal.

c. Output Form:

(1) Sine: $e_{1s} = E_1 \sqrt{2} \sin (A) \sin (2\pi ft + \phi_1)$

(2) Cos: $e_{1c} = E_2 \sqrt{2} \cos (A) \sin (2\pi ft + \phi_2)$

Where:

$E_1 = E_2 = 26V$ rms ±5 percent

A = Antenna angle

f = Ref Frequency (800 cps ±0.5 percent)

t = Time

ϕ_1 and ϕ_2 = phase shift (5° ±3° with respect to ref voltage)

d. Maximum DC Source Impedance: 300 ohms each winding

4.2.1.4.2.5 LGC Pulse Inputs. The excitation shall provide signal characteristics as follows:

4.2.1.4.2.5.1 Downlink Interface

a. Maximum Source Impedance: 100 ohms
b. Amplitude (A): 4.5±1.0V
c. Pulse Width at A/2 Point: 4±1 microsec
d. Backswing: 0
e. Risetime: 0.3 microsec max. from 10 percent to 90 percent of A
f. Repetition Rate: 50 pps (except sync pulse – 2K pps at 51.2 kc: 40 pulses 50 times per sec.)

g. Timing: (ref to A/2 point) leading edge:

(1) Start to bit sync: 19.5±5.0 μsec
(2) Bit sync to data: 1 μsec max
(3) Stop pulse: 19.5±5.0 μsec after last sync pulse
(4) There shall be 40-bit sync pulses between each start and stop pulse

4.2.1.4.2.5.2 Uplink Interface (UPLINK "0" and UPLINK "1"):

a. Source Impedance: 100 ohms -1; 10 ohms -0 max.
b. Amplitude (A): 7±3V
c. Pulse Width at A/2 Point: 3±1 μsec
d. Droop: 20 percent at 2 μsec
e. Maximum Backswing: 4V
f. Risetime: 0.2 μsec max. from 10 percent to 90 percent of A
g. Repetition Rate: 1K pps
h. Maximum Noise: No pulse - ±0.4V

4.2.1.4.2.6 ACE Bias 1 and 2. A switchable ground shall be supplied to each interface.

4.2.1.4.3 Coolant Requirements

4.2.1.4.3.1 IMU. The IMU shall be provided with water-glycol coolant at a temperature of 40° ±3°F and flow rate of 33±5 lb per hour.

4.2.1.4.3.2 PSA, CDU, PTA Headers. The PSA, CDU, and PTA cold plates shall be provided with coolant sufficient to maintain the header temperature below 70°F.

4.2.1.4.4 Inertial Component Temperature Sensor Current:

a. PIPA 6±0.12 ma dc
b. IRIG 2±0.04 ma dc

4.2.1.5 Test Data. All system test data shall be recorded on suitable reproducible forms and stored at the contractor's facility. Copies of the recorded data shall accompany the system. Where space is provided to indicate the value or specific reading obtained, the specific reading shall be recorded if a limit or limits is given for a test. Further, the initials of the individual performing the inspection shall be inserted above the value observed and recorded. If limits are not stated, it is required that the individual performing the test initial in the space provided indicating that the requirements were met.

4.2.1.6 Test Values. All test values given in Section 4 of this specification reflect allowances for instrumentation error, loads, or variation in supply voltages and frequencies.

4.2.1.7 Safety Precautions. Normal safety precautions required during testing of precision electromechanical equipment shall be followed. The following requirements shall apply upon loss of the 28 vdc to the G&N System 3200 cps power supply.

4.2.1.7.1 Component Temperature. The temperature of the inertial components shall be maintained between the following limits. If these limits are exceeded, the inertial components may be recalibrated.

a. IRIG: 120°F and 150°F
b. PIP: 115°F and 145°F

4.2.1.7.2 Suspension Power.

a. The 3200 cps suspension power shall not be off while torquing of the inertial components is taking place. If this requirement is not complied with the inertial components shall be degaussed and recalibrated.

b. The 2V, 3200 cps suspension power shall be maintained for a minimum of 3 minutes prior to pulse torquing. Suspension power shall be maintained a minimum of 1 hour prior to any inertial component parameter determination.

4.2.1.8 Test Equipment Required. The test equipment utilized in whole or part as required by the respective JDC for the test being conducted shall be in accordance with Drawing 1900030.

4.2.1.9 Jigs and Fixtures. Test probes shall not be used to make direct electrical connections to connectors of the Apollo Guidance Equipment. Jigs made up of mating connectors shall be used.

4.2.1.10 Rotary Table Alignment Requirements. The Rotary Table Tilt axis shall be aligned parallel to true east within ±1 minute, and at 0° tilt the rotary axis shall be aligned within ±2 seconds of vertical.

4.2.1.10.1 Fixture Alignment and Calibration Procedures. The procedures shall be conducted in accordance with the following JDC's.

JDC 16010	Rotary Table Leveling Calibration Test
JDC 16011	IMU Mounting Fixture Alignment Test about the X and Y Axes
JDC 16012	IMU Mounting Fixture Alignment Test about the Z axis

The rotary axis and tilt axis calibrations shall be accomplished at 3-month intervals, in accordance with the following JDC's.

JDC 19728	Rotary Table Tilt and Rotary Axis Calibration

4.2.1.11 Test Setup. The APOLLO G&N equipment shall be tested and inspected under the test conditions specified herein.

4.2.1.11.1 Assembly Requirements. The G&N System shall be assembled to the G&N Ground Support Equipment and the assembly and test equipment interconnect procedures shall be conducted in accordance with the following JDC's:

JDC	DESCRIPTION
12600	LEM G&N System Visual Inspection
12601	LGC Installation
12602	Computer Control and Reticle Dimmer Assembly Installation
12603	"A" Harness Installation
12604	LGC Buffer Assembly Installation
12605	DSKY Installation
12606	"B" Harness Installation
12608	LEM G&N System Passive Test
12610	Coolant Hose Connection
12611	G&N Coolant Supply Turnon-TurnOff
16009	IMU & PTA Mounting Fixture Installation on the Rotary Table
16013	Installation of the IMU on the IMU Mounting Fixture
16014	Installation of the pulse torquing Assembly to the PTA Holding Fixture Assembly on the Rotary Table
16017	CDU Installation
16018	PSA Installation

4.2.1.12 Test Sequence. The sequence of operations shall be as specified in Figure 2.

4.2.2 Nonconforming Units. Failure of the system to pass any examination or test of this specification shall automatically classify the unit as nonconforming. Each nonconforming unit corrected shall be reinspected. Reinspection may be limited to the test or examination which defined the nonconformance, or, when directed by the cognizant inspector, a complete retest and reexamination may be required. Nonconforming units which have not been corrected will be considered for acceptance only upon formal application by the contractor to the cognizant NASA representative.

4.3. TESTS

4.3.1 Applicable JDC's. The JDC's specified in the index of 4.1 form the acceptance test procedures of this specification.

5. PREPARATION FOR DELIVERY

5.1 GENERAL. With the exception of the IMU, preparation for delivery shall be in accordance with Specification ND1002214.

5.2 IMU Preparation for Shipment. The Inertial Measurement Unit shall be prepared for shipment in accordance with JDC12699, Post-Test Preparation of IMU for Shipment.

6. NOTES. (To be supplied)

6.1 DEFINITIONS AND ABBREVIATIONS